A FRAMEWORK TO FACILITATE THE ADOPTION OF LOAD-BEARING MASONRY (LBM) TECHNOLOGY IN THE MALAYSIAN HOUSING INDUSTRY

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By

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ABSTRACT

The utilization of technology in the construction industry has contributed to a dynamic market in the construction industry and the growth of the country. The load-bearing masonry (LBM) system has been identified as an alternative method that could potentially minimize problems at construction sites and benefit the housing companies, however, the adoption of the system is still relatively low. To encourage the adoption and implementation of the LBM building system, the factors that influence the adoption have to be addressed. The aim of this study was to develop a framework for the factors that influence the adoption of the LBM building system. The factors considered were organizational perceptions, organizational readiness, external support, and facilitating conditions. This study also investigated the role of organizational perceptions in mediating the link between the factors and the LBM building system adoption. The study drew from the technology acceptance model (TAM) and the innovation diffusion theory (IDT) for the theoretical bases to explain the LBM building system adoption. The stratified random sampling technique was applied to select the housing developer firms. A total of 118 usable questionnaires was returned for further analysis using the Structural Equation Modeling (SEM). The findings revealed that organizational perceptions influenced the adoption of the LBM building system. The results also showed that organizational readiness, external support, and facilitating conditions had significant effects on organizational perceptions. Additionally, organizational perceptions significantly mediated the relationship between organizational readiness, external support and the LBM building system adoption. In general, the findings provided a framework for the factors that influence the adoption of the LBM building system in the Malaysian housing developer firms. Finally, this study proposed several recommendations for future research, housing and construction industry.

Keywords: Malaysian housing developers, LBM building system, technology acceptance model (TAM), innovation diffusion theory (IDT)

ABSTRAK

Penggunaan teknologi dalam industri pembinaan telah menyumbang kepada pasaran yang dinamik dalam industri pembinaan dan pertumbuhan negara. Sistem Binaan Galas Beban Bangunan (LBM) telah dikenal pasti sebagai kaedah alternatif yang berpotensi mengurangkan masalah di tapak pembinaan dan memberi manfaat kepada syarikat perumahan. Namun, penggunaan sistem ini masih lagi rendah. Bagi mengalakkan penggunaan dan pelaksanaan sistem bangunan LBM, faktor-faktor yang boleh mempengaruhi perlu dibincangkan. Tujuan utama kajian ini adalah untuk mencadangkan satu kerangka kerja bagi faktor-faktor yang dapat mempengaruhi penggunaan sistem bangunan LBM. Faktor-faktor yang dipertimbangkan adalah persepsi organisasi, kesediaan organisasi, sokongan luar, dan keadaan pemudah. Kajian ini juga melibatkan peranan persepsi organisasi sebagai pengantara hubungan di antara faktor-faktor dan penggunaan sistem bangunan LBM. Kajian ini menggunakan Model Penerimaan Teknologi (TAM) dan Teori Difusi Inovasi (IDT) sebagai asas teori untuk menerangkan penggunaan sistem bangunan LBM. Teknik persampelan rawak berstrata telah digunakan untuk memilih syarikat pemaju perumahan. Sebanyak 118 soal selidik yang boleh digunakan telah dikembalikan untuk analisis selanjutnya dengan menggunakan *Structural Equation Modeling* (SEM). Dapatan kajian menunjukkan bahawa persepsi organisasi mempengaruhi penggunaan sistem bangunan LBM. Hasil kajian juga menunjukkan bahawa kesediaan organisasi, sokongan luar, dan keadaan pemudah mempunyai kesan yang besar terhadap persepsi organisasi. Seterusnya, persepsi organisasi mengantara hubungan bagi kesediaan organisasi, sokongan luar dan penggunaan sistem bangunan LBM. Secara umumnya, hasil kajian ini menyediakan satu kerangka kerja terhadap faktor-faktor yang mempengaruhi penggunaan sistem bangunan LBM dalam kalangan firma pemaju perumahan di Malaysia. Akhir sekali, kajian ini mengemukakan beberapa cadangan untuk industri perumahan, pembinaan dan juga untuk kajian yang akan datang.

Kata kunci: Pemaju perumahan di Malaysia, sistem bangunan LBM, model penerimaan teknologi (TAM), teori difusi inovasi (IDT)

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LIST OF ABBREVIATIONS

AVE- average variance extracted

BS – British Standard

CR- Composite Reliability

CIDB – Construction Industry Development Board

DV- Dependent variable

ES – External Support

FC – Facilitating Conditions

GDP - Gross Domestic Product

IBS - Industrialized Building System

IDT - Innovation Diffusion Theory

IV- independent variable

JPN - Jabatan Perumahan Negara

LBM – Load-bearing masonry System

MSJC - Masonry Standard Joint Committee

OR - Organizational Readiness

PRIMA - Perumahan Rakyat 1Malaysia

PLS –Partial Least Square

PEOU– Perceived Ease of Use

RC- reinforcement concrete

RA – Relative Advantage

REHDA - Real Estate and Housing Developers

SPNB - Syarikat Perumahan Negara

SEM – Structural Equation Modelling

TUDM -Tentera Udara Diraja Malaysia

TAM - Technology Acceptance Model

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

The Malaysian construction industry plays a huge role in the development of the country. It leads and drives the economic development and contributes to the Gross Domestic Product (GDP). For Malaysia's GDP, it contributes up to 4.0 percent growth for the year 2015 and expects to contribute about 5.5 percent growth up to the year 2020 (CIDB, 2015). In general, the growth of the construction industry is driven by the demands in civil engineering works such as infrastructure and residential sub-sectors. As an example, the residential sub-sector contributes approximately 30.0 percent of the growth in the development of high-end housing to the low-cost housing (Department of Statistics Malaysia, 2014).

Meeting the housing needs has long been the national policy in Malaysia. Housing policies and programs have been developed and implemented to enhance the homeownership rate for the country, indicating that the government is committed to providing affordable houses to enhance the prosperity of the people. To balance the needs of the residents of the medium and low-income groups, the guideline of the housing planners advises that housing developers improve their performance of the projects to be competent and effective (Economic Planner Unit, 2010).

According to the Ministry of Finance (2013), the public and private sectors have undertaken various efforts to increase ownership among the community when the government plans to build 223,000 units of affordable housing for the year 2014. The government has allocated RM578 million for 16,473 units of houses and RM146 million for 600 units of houses under to be built by Jabatan Perumahan Negara (JPN) under the *Program Perumahan Rakyat Disewa* and *Perumahan Rakyat Bersepadu*. Meanwhile, the government has allocated RM1 billion and targets 80,000 units of houses to be built and sold at 20.0 percent lower from the market price under the program *Perumahan Rakyat 1Malaysia (PR1MA).* As many as 26,122 units houses including 15,122 units of Rumah Mampu Milik, 3,000 units of Rumah Idaman Rakyat, and 8,000 units of Rumah Mesra Rakyat will be built by Syarikat Perumahan Negara (SPNB) under this program.

The government has introduced *Skim Perumahan Mampu Milik Swasta* or MyHome to encourage the involvement and participation of the private sector in the development of the lower and medium housing cost. Interested developers are offered a subsidy of RM 30,000 for a unit of the house. In this new scheme, the government has allocated a budget of RM 300 million supervised by the Ministry of Urban Wellbeing, Housing and Local Government (Ministry of Finance, 2013).

Although the governmental involvement in the housing sector has become the country's main agenda, several barriers toward achieving the goals exist. The Malaysian construction industry faces challenges in the continual increase in raw building material costs (Abdullah et al., 2010; Sambasivan & Soon, 2007). Meanwhile, CIDB (2009) reported that the cost of construction materials dramatically increased for the year 2007 and 2008 due to the global financial crisis and shall keep on increasing until the financial woes are settled. CIDB (2012) stated that the cost of cement, aggregate, mixed concrete, sand, and bricks increased from 1.6 percent to 13.3 percent for the year 2011 while the average cost was between 0.2 and 2.2 percent for the year 2012. In fact, building materials were the largest component of the housing construction cost, and according to CIDB (2012), approximately 75 percent of the total cost of a construction project is derived from raw building materials. Therefore, the adoption of optional methods for improving the productivity and reducing problems at construction sites have to be addressed. According to Alaghbari, Kadir, and Salim (2007), the adoption of an optional method should be addressed through product improvement, high value added, and meeting the standard of quality requirement. Accordingly, an alternative method such as Load-bearing masonry (LBM) building system has been suggested in the housing construction industry.

However, studies on the adoption of the LBM building system is at the initial stage specifically in developing countries such as Malaysia. The understanding of the factors that contributes to this adoption will offer a platform for the housing industry and the industry players to plan and implement appropriate strategies to improve the effectiveness and performance of the industry. Thus, this study aims to identify the factors that drive the adoption of the LBM building systemas well as propose a framework for the research.

1.2 Problem Statement

With the availability and advancement of the technology and innovation with a simple technique such as LBM building system, the housing demand could be fulfilled. Compared to the conventional method RC (reinforcement concrete), the LBM system can provide an alternative solution in reducing the construction cost and accelerating construction works (Majid, 1997: Abdullah et al. 2015).

The LBM building system has been widely adopted in developed countries. The European countries have used the unreinforced masonry and has been used approximately 15 percent to 50 percent in new housing constructions in low seismicity zone (Lourence, Asconcelos, & Gouveia, 2008). The use of the interlocking brick system, for example, has gained rapid widespread in many countries as an alternative method to conventional bricks for sustainable housing (Oti, Kinuthia, & Bai, 2009).

The adoption of technology in the construction industry has be made a dynamic market for the construction industry and encouraged the growth of the nation's and industry's economics. Construction technology also allows construction companies to enhance their profitability and international standing. Tatum (1986) noted that the adoption of the technology would assist construction firms to be competitive in the global construction demand and compete with foreign firms.

Since construction technology will benefit construction projects and companies, the Malaysian Government has been actively promoting and encouraging the use of the construction technology in construction projects. These efforts are outlined in the Construction Industry Plan 2006-2015 (CIMP 2006-2015) where construction technologies such as interlocking block system as an industrialized building system (IBS) (Sundaraj,

2007) is actively promoted. However, the adoption of the construction technology such as IBS is not widely implemented in the Malaysian construction projects (Yahya, Nur, & Shafie, 2012). Consistently, Abdullah et al. (2009 and 2015) highlighted the low adoption of LBM building system even though the construction players were aware of this system in their study. For these reasons, there is a need to reveal the factors that drive LBM building system adoption among industry players. The understanding of the potential factors would assist policy makers, government agencies and industry players in encouraging the adoption and implementation of load-bearing masonry (LBM) building system in future housing projects.

Limited studies have focused on the adoption of LBM building system. For example, Adedeji (2008) focused on two factors, i.e., cost and time. He revealed that cost and time were important reasons for the adopters' decision. Meanwhile, Agrawal et al. (2014) demonstrated that intention to adopt fly ash bricks was highly associated with the perception of its quality. There is a need to study the adoption of technology among construction firms because past investigations failed to consider perceptual factors. Only Agrawal et al. (2014) and Hartmann et al. (2008) examined the perceptions of potential adopters as a key influence on the construction technology adoption.

Rogers (2003) proposed that the adoption of technology is not influenced by actual attributes but by the perception of the adopters of the innovation. Also, Davis (1989) postulated that perceptions of or beliefs in the innovation are influential in the development of an attitude that results in the system usage behavior. Although there is strong evidence that innovation perception predicts innovation behavior intention, the relevant attributes differ between studies and settings (Tornatzky & Klien, 1982). Therefore, there is a need to investigate the perceptions of the organization such as perceived ease of use and relative advantage on the LBM building system adoption (Abdullah, 2009). Besides the perception of the potential adopters in the construction industry, limited studies have examined the antecedents of organizational perceptions of the adoption of construction technology innovation. This gap in the existing body of knowledge motivated the present study to look at the relationships between factors such as organizational readiness, external factors, and facilitating conditions and organization perceptions.

While organizational perception has been identified as an important predictor of adoption, organization readiness is also likely to influence the adoption of the technology (Hadaya & Pellerin, 2010; Mehrtens, Cragg, & Mills, 2001; Sawang & Unsworth, 2011). However, studies focusing on the relationship between organizational readiness and the perceptions in the construction technology are limited. Organizational readiness regarding resources such as financial, technology and knowledgeable staff will make firms have a good perception of the technology. Given the considerable interest of researchers in organizational readiness, it is crucial to determine its contribution to organization perception in construction technology. Also, the intervening effect of relationship perceptions on the link between organization readiness and LBM building system adoption is limited. Therefore, there is a need to investigate this relationship.

Previous studies by Al-qirim (2007) and Scupola (2009) found that external factors influenced the adoption of technology in different technological contexts. While El-Gohary

(2012) found that external factors such as competitive pressure, government influence, culture, and infrastructure influenced e-marketing adoption, he did not find a significant relationship between relative advantage and perceived ease of use. The mixed results could be due to different contexts of external support. Hence, it would be interesting to examine the relationship between the external factors and the perceptions of companies and subsequent technology adoption (Lu et al., 2003).

Facilitating conditions are another important factor in technology adoption. In this study, it was viewed as external control. According to Lu et al., (2008), facilitating conditions are crucial in regulating behavior. Government regulation and policies are critical to technology adoption (Lu et al., 2003). However, limited studies were available on the relationship between regulations and adoption even though researchers have demonstrated that facilitating conditions are likely to influence perceived ease of use and relative advantage (Lu et al., 2008). Therefore, this study examined the influence of facilitating conditions on organizational perception and subsequent adoption of the LBM building system.

The examination of these factors is important in understanding housing developers' perspective on the adoption of LBM building system. Several factors on the adoption have been investigated. However, there appear to be inconsistencies in the determinants of adoption, especially at the organization level (Orlando et al., 2013), prompting this study to assess the factors that influence the LBM building system adoption at the firm level. In doing so, the present study employed Technology Acceptance Model (TAM) and Innovation Diffusion Theory (IDT) as a basis to analyze the mediating role of organization perceptions in the relationship between organizational readiness, external support and facilitating conditions and adoption of LBM building system.

1.3 Research Questions

Based on the discussion above, this research aimed to answer the following research questions:

Do organizational perceptions (perceived ease of use and relative advantage) influence the adoption of the LBM system among housing developers in Malaysia?

Does organizational readiness influence organizational perceptions among housing developers in Malaysia?

Does external support influence organizational perceptions among housing developers in Malaysia?

Do facilitating conditions influence organizational perceptions among housing developers in Malaysia?

Do organizational perceptions (perceived ease of use and relative advantage) mediate the relationship between organizational readiness and the LBM building system adoption?

Do organizational perceptions (perceived ease of use and relative advantage) mediate the relationship between the external support and the LBM building system adoption?

Do organizational perceptions (perceived ease of use and relative advantage) mediate the relationship between the facilitating conditions and the LBM building system adoption?

Research Objectives

This study aims to develop a framework for the factors influence on the adoption of LBM building system. It proposed the organizational perceptions influenced on the adoption of LBM building system. It also wished to comprehend the effects of organizational perception antecedents of organizational readiness, external factors, and facilitating conditions. Also, to determine the mediation effect of organizational perceptions (relative advantage and perceived ease of use). Therefore, this study design to attain the following research objectives:

To examine the relationship between organizational perceptions of the LBM building system adoption among housing developers in Malaysia.

To investigate the relationship between organizational readiness and organizational perceptions.

To assess the relationship between external support and organizational perceptions.

To analyze the relationship between facilitating conditions and organizational perceptions.

To examine the mediation of organizational perceptions on the relationship between organizational readiness and the LBM building system adoption.

To investigate the mediation of organizational perceptions on the relationship between external support and the LBM building system adoption.

To examine the mediation of organizational perceptions on the relationship between facilitating conditions and the LBM building system adoption.

Significant of Study

The present study is significant for theory and practice. The study will contribute significantly toward the literature in the LBM building system in that differs from other studies that tended to focus on technical issues. Despite a growing body of literature dedicated to investigating the aspects of design, structure, and material, as well as testing of structure elements (Hendry, Sinha, & Davies, 2004; Mosele et al*.,* 2006), there is limited empirical research on the topics related to non-technical aspects such as the management research of the LBM building system. Even if any, past studies have only looked into the historical and development of masonry, masonry productivity, and sustainable masonry.

There are limited studies on the factors that would lead to the adoption of emerging construction technology. This study was conducted to examine the factors that influence the adoption of the LBM building system at decision stage process from the perspective of housing developers in Malaysia.

More importantly, this study contributes to the theoretical understanding of the factors influencing the LBM building system adoption. Since there are limited studies in this area, Theory Acceptance Model (TAM) and Innovation Diffusion Theory (IDT) theory were used to underpin the present research. According to Davis (1989), TAM is a model that predicts the adoption and rejection of technology. Meanwhile, Rogers (1995) argued that the adoption of the technology be identified by its characteristics. Therefore, TAM and IDT theories were useful in contributing to the understanding of factors affecting the LBM building system adoption.

The findings of this study are also likely to assist the construction industry, particularly the industry players as well as all other parties that are using or are planning to use the LBM building system in their future housing projects by gather information from decision makers namely housing developers on factors influencing the adoption of the LBM building system. If the findings are valid, the LBM building system needs to be designed and implemented in such a way that it perceived to be easy to use and has the relative advantage for it to adopted. Also, if the outcome of this study shows a significant relationship between organization readiness, external support and facilitating conditions and organizational perceptions, it is imperative that industry players such as housing developers improve their resources. Government support for the use of the system by the industry players is also crucial in determining favorable perceptions of the system and subsequent adoption of it.

This study is also important for various parties related to the construction industry. Government agencies such as the Construction Industry Development Board (CIDB) can take initiatives to increase training of the construction technology methods such as LBM building system and enhance the infrastructure for the housing industry players such as contractors, engineers, architects and housing developers. Additionally, the findings will assist policymakers in planning and directing future policies, plans, and strategies for the national development on how to increase the adoption of the LBM building system in the housing construction industry in Malaysia. Jabatan Perumahan Negara (JPN) and Real Estate and Housing Developers (REHDA) should grant incentives and award future projects to developers interested in using the LBM building system. Otherwise, in enhancing the knowledge of the LBM building system, local universities should take initiatives to offer subjects on the design and construction methods of the LBM building system.

Despite prices of construction materials keep increasing, the LBM building system presented an alternative solution to the housing industry and this system fits well with the Industrialised Building System (IBS) and it can be promoted as a do-it-yourself (DIY) system.

1.5 Scope of Study

This present research was conducted in Malaysia and focused on the construction industry because of the industry's contribution to the national growth and development. Industry players such as housing developers were involved in this study as decision makers in construction projects. According to Ling et al., (2007), a developer or the owner of a project plays a critical role in the construction innovation. Meanwhile, other researchers (Huovila, 1999; Majdalani, Ajam, & Mezher, 2006 ; Abidin, Yusof, & Othman, 2013), noted that it is the developer who plays an important role in developing and financing of construction projects.

The study was confined to peninsular Malaysia and private developer firms because *Jabatan Perumahan Negara* noted that housing constructions are primarily located in the peninsula and developed by the private sector (Jabatan Perumahan Negara, 2014). The list of the developer firms was obtained from the Real Estate and Housing Developers (REHDA) annual report 2014.

1.6 Operational Definitions

The definition of the key terms used in this study is as follows:

Organization perceptions

Organizational perception refers to the belief an organization has on the ease of use and relative advantage of the technological use. Perceived ease of use means the degree which an organization believes that using the LBM building system is easy to use. When a technology such as the LBM building system is perceived to be easy to use and is less complex, it is likely to be highly accepted and used by the organization.

Relative advantage

Relative advantage is defined as the organization's view that the LBM building system method is better than the traditional construction method, which is reinforcement cement (RC). The LBM building system has advantages over the traditional construction such as it is more efficient and enhances the subsequent performance of the project.

Organizational readiness

Organizational readiness refers to the availability of resources needed for the LBM building system adoption. Organization readiness means that the organization has three key resources: technology, finance, and staff. Financial resources refer to the financial capacity needed to invest in the LBM building system. Technological resources refer to the expertise and experiences the organization has with the LBM building system. Meanwhile, staff resources refer to the skill level of the employees and their knowledge of the LBM building system.

External support

External support refers to the availability of a third party support for the implementation of the LBM building system. Government support, contractor support, and supplier support are determined as key factors for the adoption of the system.

Facilitating conditions

Facilitating conditions are external controls related to the environment (Terry, Gallois, & McCamish, 1993). Behavior could not occur if the environment prevents it or makes the behavior difficult to be committed (Lu et al., 2008). Environment policies and regulation standards are viewed as external controls purported to influence the LBM building system adoption.

Load-bearing masonry (LBM) building system

Load-bearing masonry (LBM) building system is a method where the elements of a structure are built using masonry units (for example, bricks/blocks or interlocking blocks). It is a concept where the floors and walls work together as a system, and each element supports each other.

Adoption

Adoption is defined as a step taken in the process in which a decision maker makes a decision to adopt the technology (Rogers, 2003). In this study, adoption means the decision to adopt the LBM building system at the firm level. According to Sepasgozar & Davis (2016), the firm level is useful for describing and predicting technology adoption in the construction industry.

Organization of Study

This study is structured into seven (7) chapters as follows:

Chapter One: Introduction

This chapter includes the background of the study, problem statement, research objectives, research questions, significance, and scope of the study as well as the operational definition of the key terms.

Chapter Two: A Review of Load-Bearing Masonry Building System

The chapter discusses an in-depth review of the historical development of the LBM building system. It also defines the LBM building system. Then, an in-depth review of the adoption of this system and the advantages of this system in the construction industry are also provided.

Chapter Three: Factors Influencing the Adoption of the Technology

The chapter reviews he different theories of technology adoption as well as the literature related to construction technology adoption. It also evaluates the potential factors for the adoption of the LBM building system in the construction industry and provides an in-depth discussion about the theoretical framework and development of the hypotheses.

Chapter Four: Methodology of Study

The chapter explains the research philosophy and the methodology used to carry out the study toward achieving the objectives and answering the research questions. It also describes the issues related to the chosen research methodology such as the research approach, population, sample, and data collection methods. This chapter concludes by outlining the methods used to analyze the data.

Chapter Five: Data Analysis and Results

The chapter presents and interprets that the outcome of the data analysis. The pilot test results are discussed. In addition, the demographic backgrounds of the respondents are discussed in this chapter. Additionally, the Partial Least Squares Structural Equation Modeling (PLS-SEM) method was used to analyze the data and to test the hypotheses for the research model.

Chapter Six: Discussion of Findings

Chapter six discusses the results in greater detail by relating them to theory and past studies. The research implications for theory and practice, limitations of the study and suggestions for future research are also highlighted.

Chapter Seven: Conclusions and Recommendations

Lastly, chapter seven highlights the conclusions and recommendations of the study.

CHAPTER TWO

A REVIEW ON LOAD BEARING MASONRY (LBM) BUILDING SYSTEM

2.1 Introduction

This chapter discusses the details of load-bearing masonry (LBM) building system. It deals primarily with the historical development of masonry, modern structural masonry, and structural masonry in Malaysia. Then, it highlights the definitions, types of masonry structure, and the innovation of masonry. Finally, the advantages of the system are reviewed in detail.

2.2 Historical Development of Masonry

Masonry is mostly used walling material in the construction industry with several advantages, whereas the sub-division of space acts as the load carrier of the building, fire protection, and thermal and sound insulation. Masonry is a composite construction consisting of the arrangement of brick or block units, which are bonded and joined together using a mortar mixture (Abdullah, 2009).

Masonry structures have been used in the early centuries from the smallest to the biggest buildings, infrastructures, and monuments. In the earlier times, the masonry structure had no specific design. The units of brick or stone were combined with mortar to form a structure without shear walls, to increased thickness from upper to lower building. The

Pyramids of Egypt, the Mohenjo-Daro in the Indus Valley, Holy Kaaba, and Great Wall of China are examples of the great masonry structures. The classical Greek and Roman Empire offer many examples of masonry structure such as temples, palaces, houses, and bridges. The Romans introduced brick buildings in Britain, which were widely used in the residences of the British middle class in the 17th and 18th centuries.

Apart from European countries, USA also had masonry structure on their building constructions. The masonry structure based on graphical methods or simple calculation is Monadnock Building in Chicago 1891. This traditional structural masonry was designed by John Root with the walls' thickness at the base of 1.82 meter (Sinha, 2002).

The early part of the 20th century showed the development and usage of steel and concrete structural frames on construction while structural masonry functions as a load-bearing material in buildings. At that moment, the producers have faced to found load-bearing masonry system to be effective, attractive and not able to convince designers and contractor. Later, with the advanced production technique and manufacturing process, bricks were manufactured with greater strength and lighter at a fast speed (Beall, 2000). In the late of 20th century, product development of masonry system turned to fulfil the needs of contemporary constructions as well as to maintain competitiveness in the construction market.

2.3 Modern Structural Masonry

The design of modern structural masonry is based on shear walls in which longitudinal walls, transverse walls, and slabs resist together against horizontal action (Lourence et al., 2008). The walls can be used in compression and tension to resist the wind loading in any direction, and they made it possible to construct buildings with many numbers of floors. This principle moderates the thickness of the walls and makes it possible to be built in zones of low seismic hazard like in European countries where many load-bearing brickwork constructions exceed ten stories. An example of a building that uses this modern system is in Switzerland; the 18-storey load bearing wall supported on relatively thick walls of 127mm to 254mm was built in 1957. Since then, this type of construction has become the norm all over the world.

Recently, through research and development (R&D), this system comes with an innovative design. According to Mosele, Porto, and Modena (2008), innovative systems for LBM and the non-LBM system is based on the advancement of vertical reinforcement. Additionally, the fastening of mortar and concrete block and their combination with special clay and concrete block has been added to the LBM system innovation. Lourenco et al. (2008) stated that an alternative replacement for reinforced concrete structures are confined lightweight concrete masonry and reinforced hollow concrete masonry.

In addition, researchers have solved technical problems and provided modern design methods for seismic areas. This innovative design gives several advantages including new possibilities for masonry construction, more economical construction and maintenance, enhanced quality of the masonry wall, crack-free wall, and earthquake resistant constructs.

2.4 Structural Masonry in Malaysia

There are three structural systems in a building construction: frame system, flat slab system, and load-bearing system. For the frame system, beams and columns are used to support the building loads and provide stability to the building. Meanwhile, masonry act as in-fills partitions or wall and do not carry any loads. In a country such as Malaysia, most of the buildings are from reinforced concrete frame and a few use steel frame. For the load-bearing building system, the building loads carried by the walls, and the walls has two functions: partitions and structure element in providing support and stability of the building (Abdullah, 2009).

In Malaysia, masonry construction started more than 500 years ago with the coming of Portuguese to Melaka. A Famosa is an example of a masonry heritage building left by them. Then, brick masonry was widely implemented in *Tanah Melayu* with the coming of the British. Offices and middle-class residential homes are examples of buildings built by the British. Furthermore, the modern masonry construction was initiated by the British. These buildings were found located at Harvard Estate in Gurun and TUDM quarters in Jitra (Abdullah, 2009). Several of these buildings have been demolished to make way for a new development.

Block masonry structures were introduced after independence mainly in housing projects. Examples of housing projects using a hollow block are low-cost houses at Taman Sri Kemuning, Jitra, Setapak Jaya Housing Estate in Setapak, and the Selayang Utara and Selayang Selatan housing project (Abdullah, 2009). Examples of buildings using masonry system that still exist are, for instance, Bangunan Sultan Abdul Samad in Kuala Lumpur, Hospital Tun Aminah in Johor Bharu, and Bangunan Federated Malay States Railways. These buildings have been gazetted as a national heritage.

Due to the excellent record keeps for both overseas and locals, the LBM building system was approved and gazetted under the Uniform Building by Laws in 1989. In 1994, a low-cost housing project at Chembong Negeri Sembilan using this system had won the prestigious Prime Minister's Award. The award is organized by Jabatan Perumahan Negara. Since then, a few housing projects have been reported to use the LBM building system. Table 2.1 lists examples of buildings that applied the masonry system in Malaysia.

Table 2.1
Examples of Building with Masonry System in Malaysia

No.	Type of building	Years
1.	A Famosa	500 years ago due to the coming of Portuguese in Melaka. Built in 1898
2.	Bangunan Sultan Abdul Samad Kuala Lumpur	Built by British colonies in *Tanah Melayu*
3.	Bangunan Federated Malay States Railways	Built by British colonies in *Tanah Melayu*
4.	Housing projects: Low cost Taman Sri Kumuning, Jitra Housing at Setapak Housing at Selayang	Between 1970 and 1979
5.	Low-cost housing project: at Chembong Negeri Sembilan (Prime Minister's Award)	Year 1994
6.	Terrace-house from local developers: Perbadanan Kemajuan Negeri Selangor Damansara Reality PASDEC Corporation	Between 2000 and 2014

Sources: Abdullah (2009), Abdullah et al. (2015b)

2.5 Load Bearing Masonry (LBM) building System Definitions and Types

The primary use of masonry in buildings is in the walls, and the minor use is in interior and exterior designs. Masonry walls are classified into load-bearing and non-load bearing walls as presented in Figure 2.1. The non-load bearing wall contains exterior and interior infill, retaining walls, and cladding. Masonry infill is performed to fill for concrete and steel structure frame. The infill should completely fill the space between the columns of the frame. It is for the lateral load to transfer from columns to masonry infill. Meanwhile, the purpose of masonry cladding is to resist the weather. It is called exterior weather-resistant cover. It is the major determinant of the building's appearance because it delivers the image, lightness, and a sense of movement (bright).

Load-bearing masonry is also called load-bearing wall structure when the walls are required for load-bearing purposes and act as shear walls. Also, the walls function to enclose and divide spaces. It is different from concrete and steel frame structure where the frame functions for the structure and enclosing while the dividing space is performed as non-structural walls.

As mentioned earlier, load-bearing masonry wall system is the oldest construction method, and their design is based on the rule of thumb. Over time, this rule of thumb was applied to the building code based on engineering calculation design. Nowadays, several studies have applied the load-bearing masonry building system in their research, resulting in numerous definitions of load-bearing masonry. Table 2.2 lists the definitions of load-bearing masonry based on previous research.

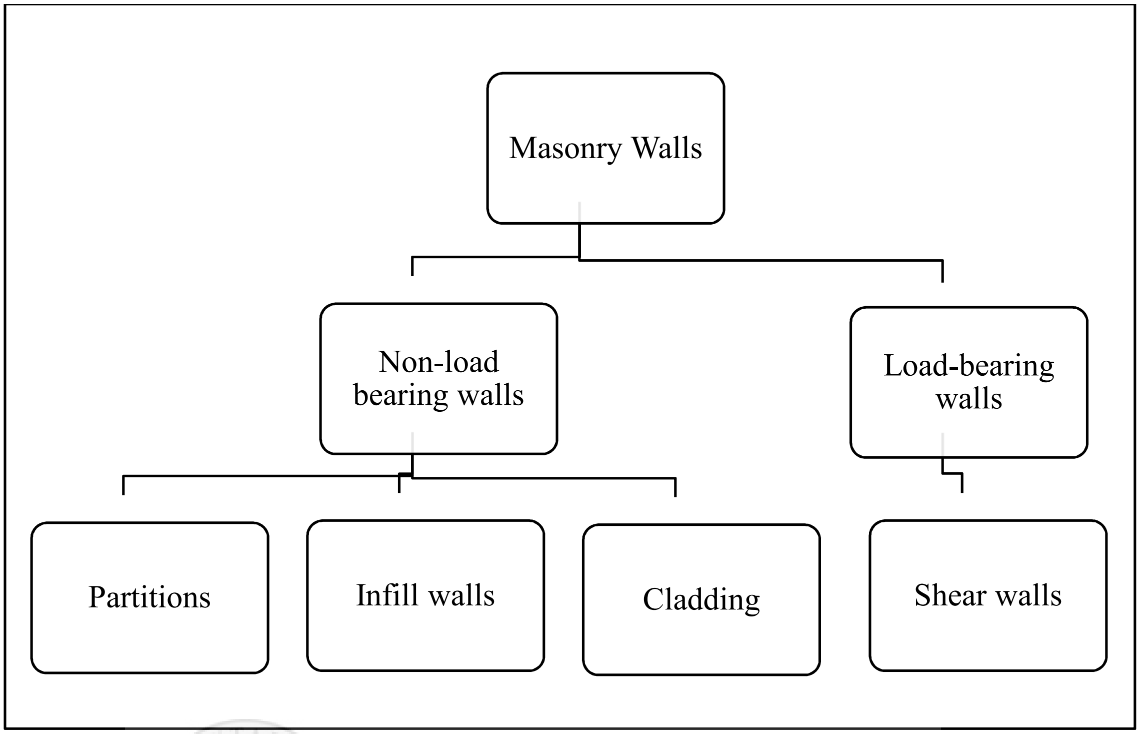


Figure 2.1
Masonry wall construction

Table2.2
Definition of Load-bearing masonry System

Type	Definition	Source
Structure masonry	Structural masonry is a method of construction where elements of a structure are built using masonry.	(Abdullah, 2009)
load-bearing building system	The masonry walls are used to support building loads imposed by the roof, upper walls and floor slabs as well as lateral loads such as wind and soil pressure.	
Load-bearing wall	A concept where the floors and walls work together as a system. Each element gives support to others.	(BIA, 1997)
	A wall that supports gravity load, self-loads and act as shear walls.	(Mehta et al., 2013)

In summary, a load-bearing masonry building system is defined as a system where the masonry components are designed to take loads from the vertical and horizontal sides of the building. The vertical load from the roof and upper floor slabs of the building and lateral loads are normally from wind and soil pressures. This system is designed according to the International Code of Practice to carry structure load and ensure the stability of a building. For design purposes, Malaysia adopts the British Standard BS 5628 (BS 5628, 2005) and Euro Code 6 (BS EN 1996, 2005). A structural element of the building can carry upper loads, and lateral loads and load can transfer through this structure to the foundation. As a result, the multi-storey structure can be built using the load-bearing masonry system.

The LBM system is different from the reinforced concrete (RC) frame system where beams and columns carry vertical loads and lateral loads, which then transfer the loads to the foundations. Walls for reinforced concrete frame system only function as a partition of space to divide the area into a few segments. For the load-bearing system, walls not only work as a partition but also function as a structure that supports and distributes the loads into the foundation. Hence, the differences between the frame system and the load-bearing masonry system are the structures that transfer all the loads from the upper floor to the base foundation.

2.5.1 Masonry Units

The term masonry is to describe the type of construction where a large number of small units are arranged with mortar to produce structure elements. In other words, masonry is the composite construction consisting of the arrangement of bricks or block units and joined together with mortar mix. The units of masonry discussed below are bricks, locks, and mortar:

Bricks

Bricks are one of the main building materials. Bricks are available in a variety of shapes, color, and types. Builders are more attracted to the color, texture, and size of the bricks. Meanwhile, designers are concerned about the bricks properties such as compressive strength, elasticity, shrinkage, and tensile strength.

One unit of brick has the following measurement: the length not exceeding 300mm, the width not exceeding 250mm, and the height or depth not exceeding its width. The normal size of bricks used in construction is 216mm x 102.5mm x 65mm.

Early bricks were made from clay and dried under the sun where the pattern and size were shaped by hand. Malaysia is a brick country, and almost all builders are familiar with the brickwork. Manufacturing companies produce a variety of bricks with different sizes, shapes, and color. The majority of bricks used by the local contraction industry are fired clay bricks and cement bricks. Fired bricks involve a manufacturing process that mixes stiff clay and red soil, with measured water and shaped using steel mould at high pressure and cut to shape using a thin wire. Cement or concrete brick is made from sand or other fine aggregates and water. The dry mix constituting about 10 percent of cement are pressed, moulded, and then air cured depending on the required quality. The cement or concrete brick is commonly used for low-cost construction due to its lower prices.

In increasing the properties of fired bricks, fly ash is used as the alternative material. In experimental studies of Lingling et al. (2005) and Watie et al. (2013), fly ash was capable of increasing the properties of fired bricks such as sufficient strength for use in a construction project, durability in diverse environments, and good in quality.

Bricks are classified into engineering, facing, and common bricks. Engineering bricks have high strength and durability and need water absorption of 7 percent and a minimum strength of 50 N/mm^2 (BS 3921). Bricks are categorized into two groups: load-bearing and non-load bearing. Bricks with a minimum compressive strength of 7 N/mm^2 are considered as load-bearing bricks that can be used to carry loads. Non-load bearing bricks are used for infill between other building elements, and they commonly have a minimum of strength 1.5N/mm^2. The majority of our local bricks are produced for non-load bearing bricks.

Blocks

Blocks commonly have a larger size than bricks. The size varies from 300mm to 600mm, width no greater than 300mm, and height not exceeding its width. Most blocks are made from concrete. Block units come in as hollow blocks, solid blocks, or cellular blocks.

Usually, blocks are larger than bricks in size, and they can be constructed faster than bricks. Concrete blocks are also categorized into two groups which are load-bearing and non-load bearing. Unreinforced load-bearing blocks have a minimum strength of 7 N/mm^2, and for non-load bearing blocks, the minimum strength is 1.4 N/mm^2.

Concrete blocks are produced from heavy, dry, fine gravel, cement, and water with a predetermined proportion and no-slump concrete is mixed with sand. To improve the properties of blocks of strength, durability, lightweight, and thermal insulation, they are manufactured using admixture, lightweight aggregates, and cement replacement, or by blending with other materials.

To improve the quality of the masonry material, fly ash is used. Agricultural ashes and waste products are mixed with cement to reduce environmental problems, save on the usage of raw materials, and because they are a cheaper alternative. Poon, Kou, and Lam

(2002) and Poon et al. (2009) used recycle aggregate from the construction site. They demonstrated that the properties of blocks such as strength and density were increased. Sukontasukkul and Chaikaew (2006) used crumb rubber to replace coarse and fine aggregates in a concrete block. They showed that the blocks became more flexible and stronger. Meanwhile, the use of fly ash and silica fume have been widely studied and applied in many of cement blocks manufacturing

Mortar

The purpose of mortar is to provide a uniform bed for laying the masonry units and to bond the units together to produce a weatherproof composite material capable of safely resisting the applied load. Mortar is produced by mixing cement together with hydrated lime and sand in specified proportions with water. Cement is to provide strength and lime is to give the degree of workability for easy laying of masonry. Mortar joint acts as a sealant, a bearing pad, and sticks the units together. Good mortar provides stability for block or brick, remains workable enough to enable the operative to set the masonry unit right to line and level, and accommodates the movement of the structure.

However, mortar has disadvantages in construction because it has lower comprehensive, tensile, and bond strength of the units and is more likely to deteriorate. To improve quality, speed, and reducing maintenance and repair costs, the innovative mortar was developed such as dry stack and thin bed. Thin bed utilizes a thin layer of cement glue mortars by connecting the dimension masonry units accurately (Thamboo & Dhanasekar, 2016). With the introduction of required materials such as bed glue, it is possible to reduce the traditional 10mm low bond mortar joint as low as 1mm (Fried et al., 2005; Walliman et al., 2008).

Thin bed or thin bed masonry construction has been practiced more than 15 years in Europe and recently thin bed masonry was used for concrete units, clay bricks, and calcium silicate units (Dhanasekar & Porto, 2009). The thin bed masonry process is more automated than the traditional masonry construction. The glue mortar bed is formed using a hand-held glue gun or a box roller and pumped along the bed ejection for the mortar to attain higher tolerance and with accurate thickness (Zeus & Popp, 2000).

The advantages of the thin bed masonry listed by Walliman, Baiche, and Ogden (2008) are higher flexural and shear strength, the opportunity for complex wall shapes, easier lifting, and transportation such as a prefabricated panel. Meanwhile, Marrocchino et al., (2009) pointed out that reductions in mortar joint improve thermal resistance where the heat flow mostly occurs through the mortar units.

Dry-stacked is the concept when the masonry is laid with un-mortared joints (Beall, 2000). The elimination of mortar reduces the problem such as shrinkage cracking. It also significantly reduces the requirement horizontal of wire steel joint. The advantages of the dry-stack masonry are the reduction of materials and labor, increased productivity, and faster construction (Atamturktur et al., 2016; Hines, 1992).

Recently, the dry-stack or other word dry-stack masonry systems were incorporated physically as interlocking of concrete masonry units. An example of dry-stack masonry is interlocking concrete masonry unit (CMU). Its use is widespread in the United States. The interlocking concrete masonry unit provides gravitational stability and makes horizontal and vertical aligning easier and faster.

2.5.2 Types of Masonry

There are several types of masonry structure in construction. This section discusses four (4) types of masonry structure commonly used: unreinforced masonry, reinforced masonry, pre-stressed masonry, and confined masonry.

Plain Masonry or unreinforced Masonry

Plain masonry or unreinforced masonry has no steel reinforcements and is simple to construct (Figure 2.2). This system relies on the strength of the masonry to bear the building load. Unreinforced masonry is designed to zero tensile stress and is used in low and medium buildings. Additionally, unreinforced masonry structure has an excellent performance record in areas that are not subjected to the extreme winds and earthquakes.

Figure 2.2
Plain Masonry or unreinforced Masonry
Source: Lourence et al. (2008)

Reinforced Masonry

Reinforced masonry is more commonly used than plain masonry. It has several advantages with little additional cost over plain masonry. Reinforced masonry has steel added in the masonry to give a tensile, bending strength, and therefore improving compressive strength.

In construction, this allows a more slender column and wall. For reinforced brickwork, steel reinforcement is encased between two layers of masonry units and bounded compositely using the ground while for reinforced blockwork, the steel reinforcement is mainly laid inside the cores then filled with grout (Figure 2.3).

Figure 2.3
Reinforced Masonry
Source: Lourence et al. (2008)

Prestressed Masonry

Prestressed masonry was first developed in concrete construction before the experienced pre-stressed concrete designers designed the pre-stressed masonry (Figure 2.4). The ideas are to load the masonry with a compressive force that will offset the expected loads such as wind loads, floor loads, and roof loads. It is best suited for walls. Masonry Standard

Joint Committee (MSJC) Code defined the pre-stressed masonry as masonry, where internal stress is introduced to counteract stresses caused by applied loads.

The post-tensioning (after the masonry is in place) is commonly compared to pre-tensioning (the masonry being constructed) because it is easier to pre-stress the masonry after it is in place. According to Cristine and Subasic (2001), there are numerous advantages of post-tensioned and pre-stressed masonry as compared to reinforced masonry. It reduces water penetration, crack, and grouting, increases lower building weight, and improves insulation.

Figure 2.4
Prestressed Masonry
Source: Cristine (2001)

Confined Masonry

The confined masonry technique is similar to reinforced masonry, which is infill wall. However, this system is different in the construction sequence (where reinforced concrete elements built as soon as the masonry wall has been completed) aspect and acts as seismic performance. Confined masonry is a system where the vertical and horizontal reinforced concrete elements of a small section are included in the masonry (Lourence et al., 2008). These confining elements are known as vertical and horizontal ties, where a vertical element (tie-columns) resembles columns in a reinforced concrete frame, but they tend to be of a smaller cross-sectional dimension. The horizontal elements (tie beams) resemble beams in a reinforced concrete frame and the horizontal beam does not work as a conventional beam where the confined masonry wall is a load-bearing frame.

2.6 Innovative Masonry Construction

Construction masonry is one of the oldest methods in the world. Compared with other construction methods, traditional masonry construction is labor intensive, costly in maintenance and repair works, which affect quality and productivity. In improving quality and in light of decreasing skilled workers, several innovation masonry construction methods were developed in recent times. These systems are load-bearing mortarless brickwork, blockwork system, and prefabricated brick masonry. These systems are widely used in the United States and Europe. These systems are discussed below.

Interlocking Brick System

Interlocking brick system or mortarless brick construction has gained significant acceptance around the world, especially in European countries. This technology is simple and local resource dependence. The interlocking brick is more suitable to local communities in India than the mortared brick technique (Sharath, Vikas, & Kumar, 2013).

The interlocking brick system has the advantages such as reduction in construction duration, labor, and construction cost (Anand & Ramamurthy, 2003). The interlocking stabilized soil brick (ISSB) is an example of the mortarless brick where it was developed with the idea of dry-stacking bricks during the construction. ISSB reduces the cost of construction about 40 percent lower than the conventional method (Kintingu, 2009). Designers have developed and analyzed the machinery for producing of different shapes and sizes of the IBBS, and they found that it improved labor skill in construction by their self-aligning (Ramamurthy & Nambiar, 2004).

Interlocking Block System

Ideally, an interlocking block system or mortarless block is outfitted for load bearing wall construction because the blocks are 220 mm in width and the block strength is more than 72 N/mm^2, which make them suitable for load-bearing construction (Deepak, 2010). This system has been used since the 1970s for housing development. It is made from sand-cement, stabilized soil, and burnt soil. The system is also widely used in countries like the United States, Europe, South Africa, and India.

The concept of the interlocking masonry system in construction is similar to the 'LEGO' concept. The block units are laid in dry conditions without any mortar included in the horizontal or vertical joints or both. This system is different from conventional bricks since it does not require mortar to be laid in masonry work because the elements on the top and bottom of the block interlock will automatically align them in making a wall (Sharath et al., 2013). The process of building works are faster and requires less skilled labor as the blocks are laid dry and lock into place. The commonly used examples in the market are Interlocking Hollow Blocks, Thai Interlocking Brick, Solbric System, and Tanzania Interlocking Brick System. Anand and Ramamurthy (2000) in their study summarized the classification of mortarless masonry system (Figure 2.5) and common interlocking blocks system used worldwide (Table 2.3). Mortaless masonry indicated in Table 2.3 eliminates mortar by utilizing interlocking geometries or non-geometric mechanism. The elimination of mortar reduces skilled workers and construction time without affecting the quality of the masonry (Adedeji, 2005).

In Malaysia, the use of interlocking block system is based on demand for low and medium cost houses where the client asks for cost savings. The first completed pilot house using this system was in Felda Laka, Kedah in 2008. One unit of bungalow house completed within 40 days. This system is ideal for integrating the production of construction, resulting in economical construction, less wastage at the site, and sustainable construction (Nasly & Yassin, 2009). Consequently, builders are becoming more interested in using this system in their housing and building projects.

Other interlocking block systems were tested at different loadings at Universiti Putra Malaysia. The system is called Putra Block (Thanoon et al., 2004). They demonstrated that the system had the comprehensive strength that met the Malaysian code requirements. The shape of the block is simple, resulting in efficiency and ease to assemble at a construction site.

Table 2.3
Types and Description of Common Interlocking Blocks

Name of system/country	Block type and material	Interlocking mechanism
Meccano system, Peru	Hollow	Non-geometric
Modified H-block, USA	Hollow	Geometric
Sparfil system, Canada	Hollow (light-weight concrete	Non-geometric
Heaner system, USA	Hollow	Geometric
WHD block, USA	Hollow	Geometric
Spartlock system, Canada	Hollow	Geometric
Solid interlocking	Solid (laetrile stabilised with cement)	Geometric

Source: Anand and Ramamurthy (2000)

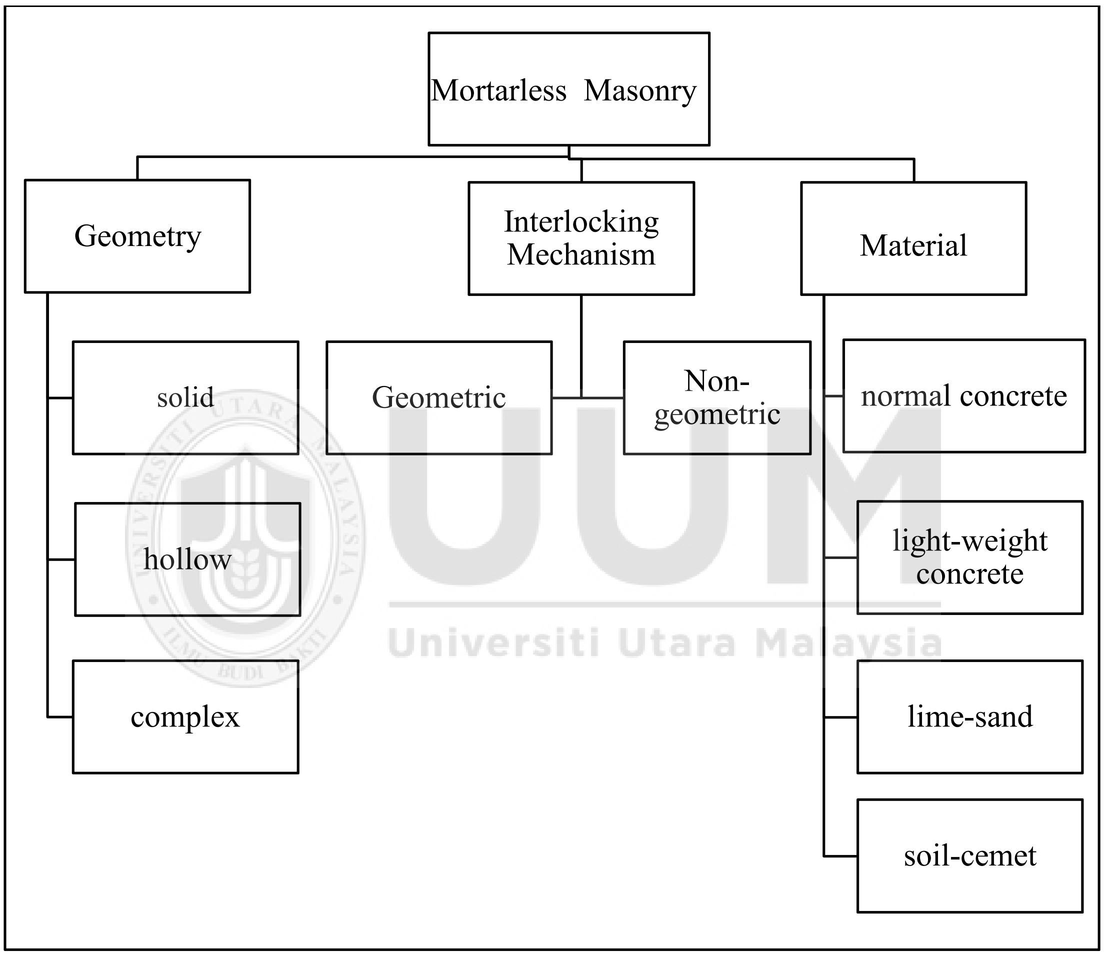


Figure 2.5
Classification of mortarless masonry system
Source: Anand and Ramamurthy (2000)

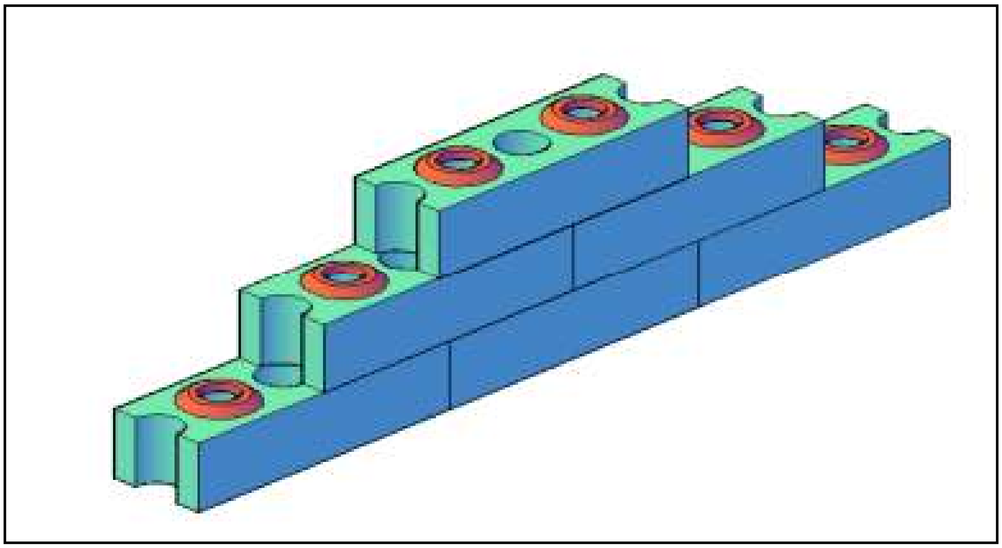


Figure 2.6
Interlocking arrangement of blocks
Source: Sayanthan, Ilamaran, Rifdy, and Nanayakkara (2013)

Prefabricated Brick Masonry

Prefabricated brickwork was developed in United of Kingdom in 1934. It later spread to Europe during the 1950s in countries such as Switzerland, Holland, and Germany. In the early method of the production, mason contractors attempted to mechanize the bricklaying process by making standard panels. Several different methods of prefabricated masonry are available. Some of the methods were similar to the traditional in-situ masonry and suitable for low-rise building (BIA, 1987). Another method developed by manufacturers was prefabricated masonry system plane. Casting method involves forming a prefabrication masonry element from dry bricks in high strength of mortar condition, then stored and cured in the manufacturing plant. This prefabricated masonry system is called as an off-site plant (Hamm, 1970). Both methods share the same target which is important to speed up works and improve productivity.

There are some advantages of prefabricated brickwork as compared to the conventional masonry method. Prefabrication reduces cost and time, enhances the effectiveness of the construction work, and provides higher quality control (Dawood, Hobbs, & Fanning, 1999). Prefabricated brick masonry also provides a good solution to the multi-dimension of common problems on the construction site such as material storage, fitted construction schedule, and quality assurance issues (BIA, 2001).

Like any construction methods, prefabrication has inherent disadvantages in that the size of the brick masonry panels is limited mainly by transportation and assembly. In some cases, the designer needs to evaluate each project by determining the feasibility and compliance of the prefabrication masonry.

2.6.1 Interlocking Block System as Industrialized Building System (IBS)

IBS is defined as a process of total integration of subsystems, components, and elements into one overall system which utilizes industrialized production, transportation, assembly, and erection on site (Nawi, Lee, & Nor, 2011). It also has been classified as an innovative process of building construction using the concept of mass-production of industrialized systems, produced at the factory or onsite within the controlled environment that includes the logistic and assembly aspect (Nawi et al., 2014). Based on these characteristics, government agencies such as the Construction Industrial Development Board (CIDB)

Malaysia categorized the interlocking block system under one of the IBS products. By doing so, Malaysia recognizes and acknowledges the use of the masonry structure in the construction industry. The classification of interlocking block system (IBS) products is shown in Table 2.4.

Table 2.4
Classification of Interlocking Block System as IBS Products

Classification	Description
Industrialized production	The interlocking block is produced from offsite using machinery and is prefabricated.
Transportation and assembly	The block units are normally transported from the manufacturing plant to the site and assembled by the blocks layer.
Fabrication and mass-production	Produced in a manufacturing or offsite with superior quality control and provides speed for construction works on site.
Structured standardization	The interlocking block system is a concept of dimensions, coordination, and positioned of block units. The use of the interlocking block encourages a modular design and standardization of building component, leading to an industrial product.
Progress integration	The standard sizing allows flexibility to integrate with other structures and thus encouraging builders to use this system in construction project.

2.7 The Advantages of LBM System

In the early years, the application of construction masonry was based on the rule of thumb. Through research and development in new materials, innovative technique, and design method, the development of standard code and practice and guide allows for a safer and economic of the masonry structure.

In developed countries, most of the residential and low-rise buildings are made from the LBM building system. With the development of traditional masonry and innovation masonry, the structure masonry systems are widely used for the construction of large span building such as factories and commercial premises.

The LBM building system offers numerous advantages compared to the conventional reinforced frame system such as cost saving, faster construction design, and sustainable construction.

Economics (cost saving)

The load bearing system can provide 10 to 20 percent savings on the total building cost compared to a conventional RC building. These savings are achieved by reducing the use of reinforced concrete and more economic foundation designs (Majid, 1997). Sinha (2002) reported that the construction cost saved is around 10 percent in Europe over other types of construction method and 7 to 9 percent cost savings per square feet per floor in the United States. Also, this system does not involve any expensive machine or costly plant. Only skilled workers are necessary for laying the bricks or blocks (Allen & Thallon, 2006;

Hendry, 2001). The LBM building system does not need additional time for preparing advanced methods at the beginning of the construction. As a result, it can reduce the cost of labor and methods.

Faster construction work

For speed, the LBM building system saves 30 to 40 percent of construction time. This is typically achieved through the elimination of the concrete framework, quick start-up of wall construction, and continuous construction due to speedy strength gained from the brickwork (Majid, 1997). In reinforced buildings, the work would have to wait until the cast concrete is strong enough before the formwork could be dismantled.

Compared to other building systems, the completion of construction using the LBM building system is about half of the frame building structure. Also, it is easy to assemble in the construction site and does not require scaffolding because the method resembles the Lego concept (Sinha, 2002).

Design

From the designers' point of view, the usage of this system is related to durability and flexibility. The durability is predicted to be working for many decades due to appropriate materials selection. The LBM building system has the longest estimated life cycle of 100 years compared to the reinforcement concrete method which is 50 years (BIA, 2004). From the architectural viewpoint, flexibility brings benefits such as greater flexibility of design plan where the layout and detailing are simple and flexible due to the repetitive floor arrangement. This technique has the versatility of the texture and pattern where it offers a limitless color, texture, and patterns of masonry units (Sinha, 2002).

Sustainable of Construction

Sustainability is concerned with promoting the most efficient use of resources, the protection of the environment and ecosystems, the use of the earth's limited resources, and the development of equitable society. These are issues of direct relevance to the global construction industry since construction uses large quantities of natural resources in terms of energy, water, materials, and land. One of the construction methods capable for sustainability is masonry construction because of the materials used (Bingel & Bown, 2009; Reddy & Jagadish, 2003).

According to El-Adaway, Breakah, and Khedr (2011), masonry contributes to sustainability through three important factors: (a) materials (bricks) are made from natural resources such as clay, (b) bricks manufacturing is located close to site (which it reduces energy, water use, and gas emission), and (c) brickwork provides acoustic comfort, thermal comfort, good indoor quality, and fire resistance.

Brickwork also meets the requirement of certificate rating systems in the field of development of density, storm water management, better energy performance, construction waste management, and low maintenance (BIA, 2009). Additionally, the masonry system produces a small scale construction and making it self-sustained (Sharath et al., 2013).

2.8 Summary

This chapter presented an overview of masonry construction. It highlighted the history and development of this system and discussed the importance and application of the system in developing countries for housing and buildings. Additionally, the definition of the LBM building system was discussed in the various arguments of the scholars. The type of the LBM building system was addressed and discussed such as i) plain masonry, ii) reinforced masonry, iii) pre-stressed masonry and iv) confined masonry. Through the research and development of the masonry the innovative masonry construction, namely as interlocking block/ brick system and prefabricated brick masonry widely used due to its advantages compared to the conventional masonry. Then, the advantages of the system were discussed regarding speed, economics, design, and product. These advantages are important to be highlighted to encourage its adoption in the construction industry. To date, very little attention has been given to the factors that influence the adoption of the LBM building system, especially in Malaysia. Consequently, the next chapter discusses those factors.

CHAPTER THREE

FACTORS INFLUENCING THE ADOPTION OF TECHNOLOGY

3.1 Introduction

Chapter three reviews previous literature related to the frameworks proposed in this study. A overview on the construction technology, technology adoption, previous study of the LBM building system and construction process is included. The next section discusses relevant theories such as technology acceptance model (TAM) and innovation diffusion theory (IDT). The discussion continues with the factors influencing the adoption of LBM building system. Based on the review and gap of the literature the hypotheses of the study and the proposed framework are presented and discusses in the next section.

3.2 Overview of Construction Technology

Technology has a broad range of definitions. Joerges (1988) described technology as artificial things that require engineering knowledge for the design and production. Technology performs many operations and can be said as practical modern machines. In a broader scope, technology can be defined as every knowledge, product, process, tool, method, and system employed in the creation of goods or in providing services (Khalil, 2000). Meanwhile, according to Tatum (1989), technology is the efforts to satisfy the material wants by working on physical objects. Ofori (1994) viewed technology as an application of the existing knowledge such as science to produce services. Skibniewski and

Zavadskas (2013) defined the technology as a collection of such tools and machines and the modification of the equipment to achieve a certain goal and carry out a specific function to solve a problem.

In construction, technology is defined as the art in construction methods, construction process, construction equipment, and materials of construction (Tatum, 1986). Table 3.1 illustrates the definition of technology. Besides the construction technology, technological innovation is also important in the development of construction. In recent years, there is a growing motion to introduce innovation technologies into the construction industry because it improves productivity, reduces the cost of construction projects, enhances safety, and increases sustainability (Loosemore, 2014). Technology innovation is defined as the use of any creating idea, practice, material, and improvement in a product or system that bring necessary changes and benefits to the investors (Slaugther, 1998).

A construction industry with a technological base is necessary for the economy because it can solve current problems such as shortage of materials and labor as well as delays in the construction. The use of technology is necessary to encourage the construction industry to compete with foreign firms (Tatum, 1986) and to address intense competition in the construction activities. The adoption of technology in the construction industry promises the development of both the economy and the industry.

The adoption and utilization of technology by construction firms are the primary sources for improvement in a competitive position, the effectiveness of design, and efficiency of a construction operation of the firms and industries as determined by practitioners at the level of the firms (Mitropoulos & Atum, 1999). The possible factors could be influenced by the decision-making process of the practitioners and may be seen from some different perspectives.

However, studies on technology adoptions in the construction industry tended to focus on the aspect of information system such as Building Information Modeling (BIM) (Arayici et al*.,* 2011; Lee, Yu, & Jeog, 2013; Linderoth, 2010), web-based training (Eadie et al., 2015; Park, Son, & Kim, 2011). Very few studies reflected on the construction tools and equipment (Goodrum et al., 2010; Sepasgozar & Davis, 2016) and innovation management (Entrop & Dewulf, 2010; Hartmann, Reymen, & Oosterom, 2008). Studies on the construction technology adoption such as industrial building system and load-bearing masonry system are also limited.As argued by Aouad, Ozorhon, and Abbott (2010), the technology adoption process in construction is different from that in other fields and needs to be developed by establishing it from various perspectives and theories. Many accepted theoretical frameworks have been used by researchers to examine the adoption and diffusion of technologies in other industries and are widely explored in the information system in various directions. The frameworks provide strong arguments for practitioners as well as academics to obtain a better understanding of the adoption and the potential utilization of the technologies (Karahanna et al., 1999).

Table 3.1
Definition of Technology

No	Definitions	Studies

1.	Technology defined as artificial things that require engineering knowledge for the design and production and perform many operations. It is practically modern machines.	Joerges (1988)
2.	Technology is an application of existing knowledge such as science to produce services.	(Tatum, 1989)
3.	Technology defined as the efforts to satisfy the material wants by working on physical objects.	(Ofori, 1994)
4.	Technology defined as every knowledge, products, process, tool, method, and system employed in the creation of goods or in providing services.	(Khalil, 2000)
5.	Technology as collection of tools, machines and modification of the equipment to achieve a certain goal and carry out a specific function to solve the problem.	(Skibniewski & Zavadskas, 2013)
6.	Construction technology defined as the art in construction methods, construction process, construction equipment, and materials.	(Tatum, 1986)

3.3 Overview of Technology Adoption Process

In general, technology adoption is defined as the introduction of something new to the organization which is externally caused (Orlando et al., 2013). Meanwhile, Khasawneh (2008) defined technology adoption as the first use or acceptance of a new technology or new products. Otherwise, Rogers (2003) defined technology adoption as the steps taken in the process through a decision maker's authorization to make a decision to accept or reject a technology.

Adoption occurs at two stages: organizational level (primary adoption) which constitutes the organizational-level decision to adopt the technology, and individual adoption (secondary adoption) that involves acceptance of the technology by individual users in the organization (Frambach & Schillewaert, 2002; Troshani & Doolin, 2005). Organizational and individual adopters are two separate concepts that include different perspectives and different levels of analysis. Based on the project nature, a construction firm applies the organizational perspective because it is useful for describing and predicting the technology adoption in the construction industry (Hartmann, 2006; Ling et al., 2007). The focus of this study was on the primary or organizational adoption to be in in line with Orlando et al., (2013) suggestion that there still appears to be no consensus on the factors influencing technology adoption at the organizational level.

The adoption of technology occurs at different phases or processes, and according to Rogers (1995), the adoption is related to the decision to accept and use the idea through five stages of the adoption process, namely, knowledge, persuasion, decision, implementation, and confirmation as shown in Figure 3.1. Meanwhile, Damanpour & Schneider (2006) stated that the adoption process is divided into three phases. They are initiation, adoption, and implementation. The initial phase or pre-adoption involves the organization members identifying and proposing a new adoption (Meyer & Goes, 1988).

Adoption reflects evaluating the proposed idea from the financial, technical, and strategic perspectives and making a decision to accept the idea in the firm (Meyer & Goes, 1988). Implementation comprises preparing, trial uses of the technology as well as acceptance and continuance of the usage of the technology in the future (Meyer & Goes, 1988; Rogers, 1995). Klein and Sorra (1996) categorized adoption into five phases: awareness, selection, adoption, implementation, and routinization. Additionally, Zaltman, Duncan, and Holbek (1973) suggested five phases of adoption: knowledge awareness, attitude formation, decision, initial implementation, and sustained implementation.

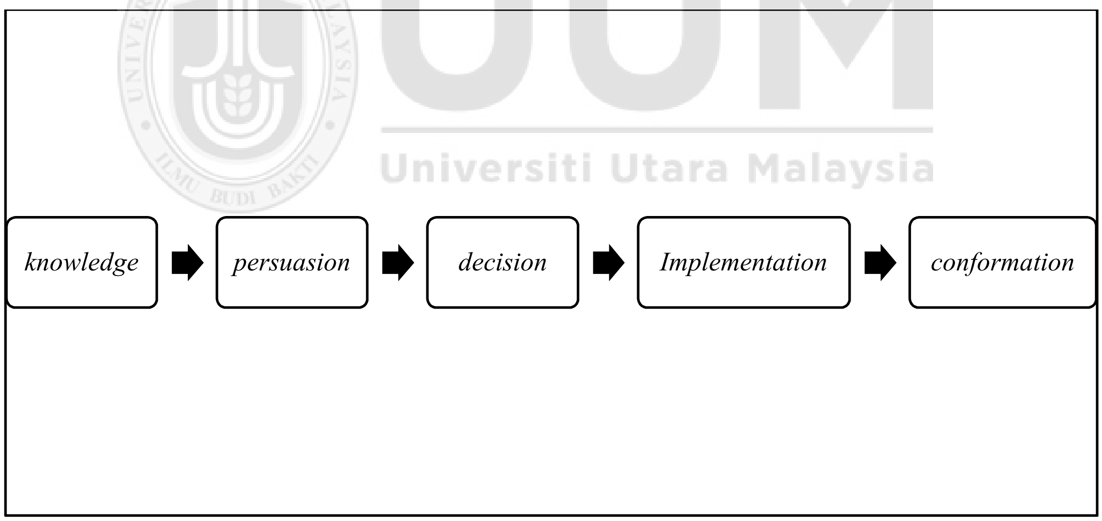


Figure 3.1
Five stages of adoption process
Source: Rogers (1995)

These following statement describes the five state of the technology adoption process adopted from Rogers (1995):

Knowledge – occur when an individual or decision-making unit exposed to an innovation's existence and understanding how its functions.

Persuasion - occur when an individual or decision-making unit forms a favorable or unfavorable attitude toward the innovation

Decision - occur when an individual or decision-making unit engages to a choice to adopt or reject the innovation

Implementation - occur when an individual or decision-making unit puts the innovation to use

Confirmation - occur when an individual or decision-making unit evaluates the results of an innovation – decision already made.

This study concerned with the decision to adopt a technology by an organization. In this study, the decision to adopt refers to the choice of adopting the LBM building system technology in the housing construction activities. The focus is on the decision stage because this stage is specifically critical and has to be managed properly before the organization implements the technology. According to Takim, Harris, and Nawawi (2013), the adoption of technology usually begins from an official decision made by the organization. Particularly, in the industries with complex systems and product, the generation of a new idea often begins with the adoption process. According to Rogers (1995), the condition for a decision to adopt requires the individual or organization to search for information to reduce the uncertainty associated with the idea. In seeking for information, a perception of innovation that informs the decision to adopt or reject is developed (Rogers, 2003).

In summary, the decision stage is crucial before applying any technology solutions. The concern here is regarding the factors influencing the decision of the industry player to implement the LBM building system for their project.

3.4 Factors Influencing the Adoption of Construction Technology

A comprehensive review of the literature related to construction technology and LBM building system adoption was conducted. The innovation in construction technologies has a slow growth compared to other fields such as information and communication technology (Yu, Wu, & Huang, 2009). As a result, the literature on the adoption and usage of the technology in the construction industry for the period of 1986 to 2010 is limited. However, based on the limited literature, Table 3.2 shows the potential factors influencing the adoption of technology in organizations.

In addition to technology acceptance model (TAM) and innovation diffusion theory (IDT), other factors that could potentially influence technology is the technology itself (Samad & Bernold, 2012). Past studies also identified that construction firms could serve as a driving factor for the new technology adoption. Studies by Dikmen, Birgonul, and Artuk (2005) and Tatum (1988) showed the organizational factors that influence the adoption of technology. Organizational resources such as finance, technology, and experienced and knowledgeable workers were also found to influence a new technology (Blayse & Menley, 2004).

Firms with staff members who have a good attitude and are persistent in increasing productivity and competitiveness will find ways to improve and promote a culture in their organization (Goodrum & Haas, 2000). Studies by Dikmen et al*.,* (2005) found that organizational culture is one of the factors that drive the adoption of the technology in the construction industry. Individual factors such as innovativeness and leaders who are energetic and eager with the potential of the technology can influence the organization to take risks in adopting the technology (Dikmen et al*.,* 2005; Mitropoulos & Atum, 1999).

The success of technology usage in the construction industry also depends on factors in the external environment such as regulation standards (Blayse & Menley, 2004). Policies and regulation that require the adoption of a new technology will not increase the risk to the construction workers or the public. Another factor is product characteristics (Tatum, 1986). The nature of the product such as the durability of the building tends to create the conditions for the adoption of technology (Blayse & Menley, 2004).

Table 3.2
Factors Influencing the Adoption of Construction Technology

	Factors Influences	**Studies**
TAM	Perceived Ease of Use Perceived Usefulness	((Lee et al., 2013; Majid et al., 2011)
IDT	Relative Advantage	(Koebel, McCoy, Sanderford, Franck, & Keefe, 2015; Sanderford, Keefe, Koebel, & McCoy, 2015)
Other factors	Technology	(Samad & Bernold, 2012)

Organizational factors	(Dikmen et al., 2005)
Organizational resources	(Blayse & Menley, 2004)
Organizational culture	(Dikmen et al., 2005)
Individual factors	(Dikmen et al., 2005; Mitropoulos & Atum, 1999)
External sources	(Dikmen et al., 2005)
Regulation standard	(Blayse & Menley, 2004)
Product characteristics	(Tatum, 1986)

Table 3.2 shows that technology acceptance model (TAM) and innovation diffusion theory (IDT) are not the only frameworks used to explain the adoption of a construction technology. Other factors have also been examined. In the TAM model, perceived ease of use and perceived usefulness were suggested potential factor for adopting the industrialization building system (IBS) and building information modeling (BIM). For the IDT, relative advantage were suggested as a factor for green building technology. Also, other factors influencing the adoption of construction technology are the technology itself, organizational factors, organizational culture, product characteristics, and organization readiness. External factors include external resources and regulation standards that are purported to influence the adoption of construction technology.

3.5 Previous Study of LBM System

Several factors influence the adoption of new methods or technologies in construction. Research in the field of the LBM system adoption is still limited. The literature demonstrates that the majority of the research were conducted on technical issues such as the design structure or material testing of structural elements (Hendry et al., 2004; Mosele et al., 2006). Watile, Deshmukh, and Muley (2014) studied the performance strength of interlocking bricks and block. Meanwhile, Lin et al., (2016) were concerned with the performance of dry stack masonry plane and reinforcement concrete frame. Studies on the management issues such as the potential factors in the adoption of the masonry structure are limited. The literature review performed, however, suggests the increasing interest in the adoption of the LBM building system in India, Nigeria, and Malaysia (Agrawal, Loya, & Rawani, 2014; Adedeji, 2008; Abdullah et al., 2009).

Studies on the masonry structure were primarily about the development and historical evolution of the system (Beall, 2000; Sinha, 2002). Others studied the sustainability of masonry (Adedeji, 2012; El- Adaway et al., 2011; Sharath et al., 2013). Other researchers discussed the development of the interlocking block system (Nasly & Yassin, 2009; Thanoon et al., 2004). The literature indicates that factors influencing the adoption of this system by the industry players are not extensively studied, particularly in the Malaysian context. An initial understanding of the factors influencing the adoption of the LBM building system in a construction organization would help practitioners and government to enhance the usage of the system in construction activities.

Table 3.3
Previous Study of LBM system

No	Area of Studies	Authors
1.	Historical and development of masonry	(Beall, 2000; Sinha, 2002)
2.	Masonry Productivity	(Sanders & Thomas, 1992, 1993)
3.	Sustainable masonry	(Adedeji, 2012; El- Adaway et al., 2011; Sharath et al., 2013; (Bingel & Bown, 2009)
4.	The use of interlocking masonry for housing construction	(Adedeji, 2008; Adedeji, 2011)
5.	The development of interlocking blocks system	(Nasly & Yassin, 2009; Thanoon et al., 2004)
6.	The advantages of masonry system	(Sinha, 2002)
7.	The adoption of masonry system in construction	(Abdullah et al., 2009; Adedeji, 2008; Agrawal et al., 2014)
8.	Design structure and material testing	(Hendry et al., 2004; Mosele et al., 2006).
9.	Performance strength of interlocking bricks and block	(Watile et al., 2014)
10.	Performance of dry stack masonry plane and reinforcement concrete frame.	(Lin et al., 2016)

3.6 Technology Acceptance Model (TAM)

TAM was established more than 20 years ago. It was introduced by Davis (1986) in his study to describe the acceptance, usage, and adoption of information technology. Davis developed this model based on Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975) but in the area of information systems. Theory of Reasoned Action (TRA) was formulated from social psychology, and it attempts to explain why individuals engage in the intended behavior. Fishbein and Ajzen (1975) argued that an attitude toward a behavior and subject norm be two key factors impacting behavioral intention and subsequent behavior. The belief-attitude-intention-behavior relationship can determine user acceptance of information technology (Lederer et al., 2000).

From Davis's point of view, information technology adoption is affected by use-related beliefs. His model stresses on two beliefs. They are perceived usefulness and perceived ease of use. Perceived usefulness is defined as the degree to which a person believes that using a particular system would enhance his or her job performance. Perceived ease of use, on the other hand, refers to the degree to which a person believes that using a particular system would be free of effort. In the model are two other constructs. They are attitude towards the use and behavioral intention to use. The four constructs lead to the dependent variable which is actual usage of IT. The model is illustrated in Figure 3.2.

However, recent studies using TAM as their framework have suggested excluding attitude since it was found not to influence the effect of perceived ease of use and perceived usefulness on behavioral intention (Giovanis, Binioris, & Polychronopoulos, 2012; Ooi & Tan, 2016; Venkatesh, 1999). In the beginning, Davis (1989) found a weak link between perceived usefulness and attitude. He later dropped attitude from the final model. The modified TAM, called TAM 2, was then tested in technology adoption and had performed well in predicting behavior (Koufaris, 2002; Venkatesh & Davis, 2000; Venkatesh & Morris, 2000). A review by Legris, Ingham, and Collerette (2003) found that 3 out of 22 studies excluded attitude from their framework. Mccloskey (2003) concluded that perceived ease of use and perceived usefulness had an impact on e-commerce adoption. Also, Gefen (2003) illustrated that perceived ease of use and perceived usefulness were major predictors of the adoption of online shopping. Following the results and recommendations of past studies, this study did not consider attitude.

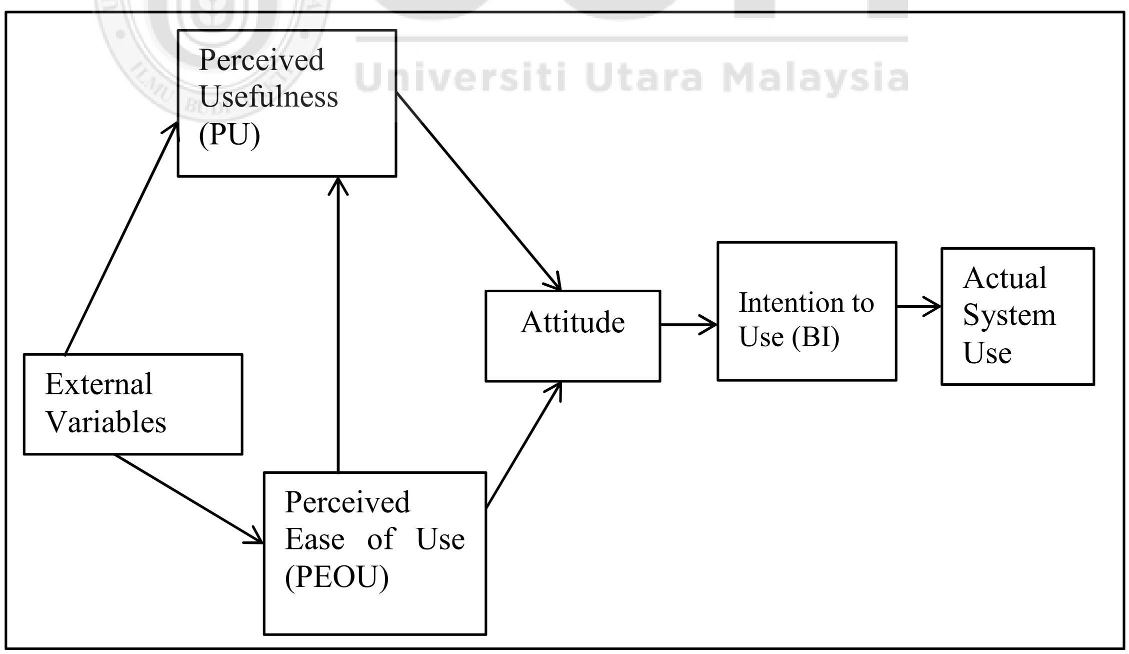


Figure 3.2
The Technology Acceptance Model (TAM)
Source: Davis et al. (1989)

Various researchers have used the TAM model for understanding the adoption of information technology. TAM becomes one of the most significant models in contributing toward a theoretical understanding of the adoption behaviors in different fields. However, a review of the literature in construction indicates that TAM has limited application in construction technology. Recently, only Majid et al., (2008) used TAM to predict the adoption of the industrialized building system (IBS). Hence, it is possible to apply TAM in the context of this study. In this regard, the present study is different from past research that has employed TAM in information systems. As proposed by Abdullah et al., (2009), perceived ease of use has the potential to influence the LBM building system adoption.

3.7 Innovation Diffusion Theory (IDT)

Innovation Diffusion Theory (IDT) is a popular theory in the diffusion of new technology, and it appears to be the most widely accepted model by researchers. The concept was introduced by Rogers (1995). Five diffusion research can be identified from the literature, namely, on how early innovation is known, the rate of adoption in different social systems, opinion leadership, diffusion networks, communication channel use, and the consequences of innovation. According to Rogers (1995), diffusion is the process by which an innovation is communicated through certain channels over time among the associates of a social system. Meanwhile, innovation refers to an idea, practices or objects that are perceived as new by an individual or another unit of the adoption.

The main contribution of Innovation Diffusion Theory (IDT) is the set of innovation attributes that it provides. In the study of technology adoption, the IDT model has been used to understand the influence of people's perception of the attributes of innovation. In Rogers' IDT (1983), five attributes were found to affect the rate of adoption, namely, relative advantage, compatibility, complexity, observability, and trialability, and these five attributes explained technology adoption significantly (Kapoor, Dwivedi, & Williams, 2014). The following lists the five attributes of technology adoption in IDT:

Relative advantage is the degree to which an innovation is perceived as being better than it supersedes.(P: 212)

Compatibility is the degree to which an innovation is perceived as being consistent with the existing values, needs and past experiences of potential adopters (P: 224)

Complexity is the degree to which an innovation is perceived as relatively difficult to understand and use (P: 242)

Trialability is the degree to which an innovation may be experimented with on a limited basis. (P: 243)

Observability is the degree to which the results of an innovation are observable to others. (P: 244)

A large number of researchers have used the IDT model introduced in 1983. For example, Premkumar and Roberts (1999) demonstrated that relative advantages, top management support, organization size, external pressure, and competitive pressure were important elements in determining the adoption of the technology. Meanwhile, Al-Qirim (2007) found technology (relative advantage, cost, and compatibility), organization factors (size and information intensity of product/services), individual factors (CEO's innovativeness and CEO's involvement), and environmental factors (competition, external support, and pressure from the supplier) significantly affected e-commerce adoption. Ramdani, Kawalek, and Lorenzo (2009) found that greater relative advantage, trialability, top management support, organization readiness, and size of the firm influenced SME adoption of a new technology significantly. The IDT theory has also been tested in IT and IS contexts (Cheung, Wong, & Wu, 2011; Nazari, Khosravi, & Babalhavaeji, 2013; Ramayah et al., 2013).

Many scholars have used five attributes to explain technology adoption. The most consistent factor of technology adoption found was relative advantage (Kapoor, Dwivedi, & Williams, 2014). Relative advantage refers to the idea that innovation can offer benefits to the organization as compared to the use of a traditional method. The load-bearing masonry building system provides benefits such as potential minimization of labor and cost of the construction compared to the existing construction method which is reinforced concrete (RC) (Assiamah, Abeka, & Agyeman, 2016).

Like TAM, IDT was not widely applied in the field of construction technology. Abdullah (2009) suggested that more studies need to be conducted to test the framework in the context of construction technology with relative advantage being one of the factors that should be considered in the LBM building system adoption.

3.8 Combination TAM and IDT

Numerous authors and scholars have extended both TAM and IDT models to enhance the ability of the models to predict new technology use and adoption. The combined TAM and IDT was found to offer a strong prediction and explanation in technology adoption (Chang, 2008; Wu, Wang, & Lin, 2007).

The TAM and IDT models have been widely tested in information technology (IT) and information system (IS) studies, and they were found to be significant in predicting internet use (Chen, Gillenson, & Sherrell, 2002; Oh, Ahn, & Kim, 2003), e-commerce adoption (Chen & Tan, 2004; Vijayasarathy, 2004) and enterprise resource planning (Calisir, Gumussoy, & Bayram, 2009). Kou and Lee (2011), in their study on knowledge management system, revealed that TAM factors, i.e., perceived ease of use and perceived usefulness, and an IDT factor, i.e., compatibility, significantly predicted behavioral intention. A study by Tung, Chang, and Chou (2008) in the area of electronic logistics information system in the medical industry showed that perceived ease of use, perceived usefulness, compatibility, and trust influenced the adoption of the system. An empirical study by Giovanis et al., (2012) showed that TAM and IDT models significantly explained the adoption of internet banking in Greece. Table 3.3 below illustrates the combination of TAM and IDT models in previous studies in different fields.

Even though TAM and IDT have been employed to explain the adoption in different disciplines, studies in the area of construction technology using the models are limited. Additionally, research regarding other factors within and outside the organization is still lacking (El-gohary, 2012). Hence, motivated by the approach to combine TAM and IDT and their limited implementation in the field of construction technology, this study used the TAM and IDT models to explain the intention to adopt the LBM building system. In doing so, other factors relevant to the construction technology that may have an influence on TAM and IDT were also incorporated.

Table 3.4
The Extension of TAM and IDT

No.	Area of Study	Authors
1.	Cloud computing	(Gupta, Seetharaman, & Raj, 2013)
2.	Open source of software	(Bhatiasevi & Krairit, 2013)
3.	E-marketing	(El-gohary, 2012; Iqbal & El-Gohary, 2014; Kanchanatanee, Suwanno, & Jarernvongrayab, 2014)
4.	Internet banking services	(Giovanis et al., 2012)
5.	Knowledge management system	(Kou & Lee, 2011)
6.	Smart watches	(Kim & Shin, 2014)
7.	Electronic-enabled manufacturing supply chain	(So & Sun, 2011)
8.	Enterprise resource planning (ERP)	(Calisir et al., 2009)
9.	Electronic logistics information system	(Tung et al., 2008)
10.	Mobile commerce	(Wu & Wang, 2005)
11.	Online mass customization	(Lee & Chang, 2011)

12.	E-invoicing	(Hernandez-ortega, 2012)

3.9 The Utilizations of TAM and IDT

In this study, TAM and IDT were considered to identify the factors postulated to affect the adoption of the LBM system by industry players. The TAM model has been widely tested in information technology, financial transactions, web-based training, and other fields related to information systems. However, studies using the TAM model in the construction industry are scarce. However, Majid et al., (2008) found that the TAM model significantly explained the construction technology which is the industrial building system. Therefore, TAM was considered appropriate in examining the adoption of the LBM building system by industry players.

On the other hand, the innovation diffusion theory IDT is a theory that postulates how and why a certain innovation is diffused into the social system (Rogers, 2003) and might help explain how technology is incorporated in construction firms. In this regard, LBM is considered innovative because it can replace the traditional construction method practices and advance through innovative design. Consequently, the innovation diffusion theory assists in understanding the decision to adopt the LBM building system by the industry players.

Based on the previous discussion that TAM and IDT could complement each other in research, combining the TAM and IDT models to investigate the adoption the LBM building system by industry players is a valid approach to adopt in this study. Moore and Benbasat (1991) suggested that perceived usefulness should be replaced by relative advantage. The reason being perceived usefulness is a broad term while relative advantage has an intuitive appeal because it is a general concept. Relative advantage was consistently found to influence the adoption of new technology. Studies conducted by Al-qirim (2007), Grandon and Pearson (2004), Iacovou, Benbasat, and Dexter (1995), Kuan and Chau (2001), Riemenschneider, Harrison, and Peter (2003) revealed that relative advantage significantly influenced the adoption of technology. Meanwhile, perceived ease of use as a construct in the TAM model would replace complexity of the technology in the IDT model. Hence, perceived ease of use and relative advantage were considered as the key constructs postulated to affect the adoption of the LBM system in this study.

Generally, researchers using the TAM model tended to work at the individual level of analysis. In this study, the focus was the business level because a business consists of a group of individuals, which also means that a business behavior is the collective behavior of individuals. Thus, perceived ease of use at the business level in TAM is defined as the degree in which an organization believes that using the LBM system would be easy to work with. Meanwhile, relative advantage is defined as the degree in which an organization believes that using the LBM building system method is better than using the traditional construction method, which is reinforcement cement.

3.10 Organization Perceptions

The technology acceptance model (TAM) and theory of reasoned action (TRA) postulate that perceptions or beliefs about innovation are instrumental in the development of an attitude that eventually results in actual behavior. In contrast, Agarwal and Prasad (1998) proposed that the perception of using innovation is key in influencing adoption. Meanwhile, Rogers (1995) viewed that a decision-making process is potentially able to develop a certain perception of innovation which influences the decision to adopt the technology.

Empirical works in information technology widely suggest that perceptions are directly linked to the adoption decision (Duan et al., 2010; Henderson, Sheetz, & Trinkle, 2012; Ramayah et al., 2013). In construction, several research works captured clients' perception of innovation (Menley & McFallan, 2006; Sexton & Aouad, 2006). Studies on industry players such as developers' perception of innovation characteristics and other factors in influencing construction technology adoption are limited (Hartmann et al*.,* 2008). Hence, this study proposed two key characteristics: perceived ease of use and relative advantage postulated to explain and predict the adoption of the LBM system. The characteristics were drawn from TAM and IDT models. Other factors such as organizational readiness, external factors, and facilitating conditions were also proposed to explain organizational perceptions.

3.10.1 Perceived Ease of Use

In TAM, the actual behavior of an individual to adopt a technology can be predicted by perceived ease of use, which is defined as the degree to which a person believes that using a particular system would be free of effort (Davis, 1989). Many studies have demonstrated that the level of adoption increases by the ease of use of a particular system (Davis, 1989; Henderson and Devitt, 2003; Nan et al., 2008; Lowry, 2003). The easier a method or technique to be used, the higher the chances that the technology will be adopted.

Previous findings on TAM 2 reported by Venkatesh and Morris (2000) showed the importance of perceived ease of use in determining the organization's adoption and use of the new technology. Perceived ease of use has also been widely found to have a positive effect on the adoption of technology in various fields (Bhatiasevi & Krairit, 2013; Li et al., 2012; Rokhman, 2011). Table 3.6 shows the relationship between perceived of use and the adopt in various areas.

Table 3.5
Relationship of Perceived ease of use and Adoption

No	Research area	Studies
1.	Mobile payment	(Kim, Mirusmonov, & Lee, 2010; Ooi & Tan, 2016)
2.	Electronic transactions	(Al-gahtani, 2011)
3.	Web-based training	(Park et al., 2011)
4.	Computer-based assessment (CBA)	(Terzis & Economides, 2011a, 2011b)
5.	E-library	(Jeong, 2011)
6.	Financial services	(McKechnie, Winklhofer, & Ennew, 2006)
7.	WebCT	(Sanchez-franco, 2010)
8.	E-shopping	(Ha & Stoel, 2009)
9.	Information system	(Dutot, 2015; Pai & Huang, 2011)
10.	Internet Banking	(Alalwan et al., 2016; Rawashdeh, 2015)
11.	Learning management system	(Schoonenboom, 2014)
12.	Enterprise 2.0 applications	(Wang et al., 2013)

Previous research indicates that the use LBM is encouraged because it is easy to handle and requires a few workers on site (Majid, 1997; Mehta et al., 2013). The decision to adopt a technology (load bearing masonry system) in the organization is predicted by the perception of the ease of use. Perceived ease of use for this study is defined as the degree which an organization believes that using the LBM building system would make it easier for the construction work activities.

3.10.2 Relative Advantage

Past research shows that innovation attributes are the major factors accounting for the adoption or non-adoption decisions of an organization. Relative advantage is one of the innovation attributes. It is defined as an innovation in the degree to which an innovation is perceived as better than the idea it supersedes (Rogers, 1995). Relative advantage covers factors such as economic profitability or social reputation that determine the degree to which a new idea is perceived better than the solutions previously used for the same purpose. Studies have found that relative advantage is a significant variable and positively related to the adoption of the technology (Al-qirim, 2007; Henderson et al., 2012; Lowry, 2002; Premkumar & Roberts, 1999; Rokhman, 2011; Thong & Yap, 1995).

A rational decision for adoption in an organization involves evaluating the advantage of the technology. Abdullah (2009) proposed relative advantage as a factor influencing the adoption of the LBM building system. The LBM building system provides several benefits to the adopters such as reduced construction time, enhanced project performance, and minimized construction works. According to Adedeji (2012), a masonry system could improve the efficiency of the construction activities. However, empirical studies that investigated this factor are limited. Thus, relative advantage was proposed as a factor influencing the LBM building system adoption in this study. Relative advantage is defined as the organization's view that believes that the LBM building system method is better than the traditional construction method which is reinforcement cement (RC).

3.10.3 The Relationship between Organisation Perceptions and Adoption of Load-bearing Masonry (LBM) system.

An organizational perception is defined as an organization's belief regarding the perceived technological elements. The technological elements in this study are perceived ease of use and relative advantage. While perceived ease of use is drawn from TAM relative advantage is from IDT. Both of these elements were postulated to influence the LBM system adoption.

Mixed results exist on the influence of organizational perception on adoption. While some researchers have indicated that relative advantage has a negative effect on adoption (Duan et al., 2010; El-gohary, 2012; Kassim, Ramayah, & Kurnia, 2012), others found a positive impact (Henderson et al., 2012; Ramayah et al., 2013). In the case of perceived ease of use, some studies have shown it to have a significant influence on the adoption of a technology (Boakye, McGinnis, & Prybutok, 2014; Davis et al., 1989; Li et al., 2012). Others, however, revealed no significant link to technology adoption (Lin & Lin, 2014).

Regarding to the inconsistent results, this study aimed at examining the organizational perceptions namely perceived ease of use and relative advantage on the LBM system adoption. Thus, the following hypothesis was formulated:

H1: Organizational perceptions have a significant effect on the adoption of the load-bearing masonry (LBM) system.

3.11 Organizational Readiness

Several studies suggest that organizational readiness is an important component in technology adoption. According to Tsai and Tang (2012), organizational readiness is defined as internal characteristics and properties of a firm and play an important role in the decision to adopt a technology. Iacovou et al. (1995) defined organizational readiness as the availability of the necessary organizational resources for adoption. They divided organizational readiness into two levels, i.e., financial and technological resources. If the organizations have sufficient financial and technological resources, they are likely to adopt a technology. Additionally, Alam (2009), Grandon and Pearson (2004), and Ramdani, Kawalek, and Lorenzo (2009) noted that technological resources and financial resources are important factors that influence the adoption of the new technology. In their study, Tsai and Tang (2012) revealed that the adoption of radio frequency was influenced by technology as well as financial and organizational resources.

Technological resources are defined as the firm being technologically ready to adopt a technological innovation while financial resources reflect an organization's capital available to invest in technological innovations (Chwelos, Benbasat, & Dexter, 2001). Blayse and Manley (2004) argued that organizational resources such as employees' knowledge can contribute towards construction innovation.

In contrast, a lack of knowledge among industry players contributes to the minimum number of adoption of the LBM system in Malaysia (Abdullah et al., 2009). The more an organization possesses financial, technological, and knowledge resources, the more likely the organization will adopt the new technology. In this study, organizational readiness is defined as shown Table 3.6.

Table 3.6
Classification of Organization Readiness

Factor	Description	Sources
Employee resources	Concern the skill level of the employees and the knowledge of the LBM system.	(Hadaya & Pellerin, 2010; Halawani, Abdullah, Rahman, & Halawani, 2013; Iacovou et al., 1995; Mehrtens et al., 2001)
Finance resources	Refer to the financial resources required for investment. They include the cost of training, module, and software development.	(Hadaya & Pellerin, 2010; Halawani et al., 2013; Iacovou et al., 1995; Mehrtens et al., 2001)
Technology resources	Refer to the organization's expert and experience with the LBM system and the module related to the system.	(Chwelos et al., 2001; Hadaya & Pellerin, 2010; Halawani et al., 2013; Iacovou et al., 1995; Mehrtens et al., 2001; Premkumar and Ramamurthy, 1995)

3.11.1 The Relationship between Organizational Readiness and Organisation Perceptions.

Internal factors have been found to be positively related to system usage (Grandon & Pearson, 2004; Iacovou et al., 1995; Tsai & Tang, 2012). Internal factors such as organizational support were demonstrated to positively affect the adoption of technology through behavior (Igbaria et al., 1997). In contrast, Park et al. (2011) found a non-significant relationship between organizational factors and relative advantage. Lee et al., (2011) found that organizational support did not influence the adoption of technology through perceived ease of use, and they suggested examining the effects of organizational support on perceived ease of use.

Prior researchers have identified the influence of organizational readiness on the adoption of technology, but limited studies have examined the effect of this factor on the adoption intention of technology. This study proposes that organizational readiness shapes organizational perceptions; hence, the following hypothesis was developed:

H2: Organisational readiness has a significant effect on organization perceptions.

3.12 External Support

External support refers to the availability of support in implementing and using the technology (Premkumar & Robert, 1999). Various studies found external factors to be positively related to the adoption of a new technology (Al-qirim, 2007; Jeon, Han, & Lee, 2006; Looi, 2004; Premkumar & Roberts, 1999; Scupola, 2009; Thong & Yap, 1995). Construction technology studies often noted the importance of external factors in the adoption of technology. Sanderford et al. (2015) demonstrated the strong effect of organizational support on the adoption of building products. Deng et al. (2005) asserted that external support influences construction innovation.

In this study, external support refers to the availability of a third party support for implementing and using the LBM system. The third party support such as the government, contractor, and supplier is significant in determining the usage of this system in a construction project (Blayse & Menley, 2004). Industry players are willing to use certain systems if they feel there is adequate external support from the government, contractor, and supplier.

3.12.1 Government support

Government support has been shown to be the most powerful institution that forces and shapes faster technology adoption (Gefen, 2003; Jutla, Bodorik, & Dhaliwal, 2002; Kuan & Chau, 2001; Tsai & Tang, 2012). Simpson and Docherty (2004) proposed that government support and initiative will increase business success. Ahuja and Thatcher (2005) and Oxley and Yeung (2001) argued that government support plays a critical role in determining the adoption of new technology in an organization. Goh (1995) noted that the government could act as interference and play the leadership role in the adoption of innovation. The government can encourage the adoption of technology by providing necessary training, independent advice and technical support to the organization. Several studies revealed that government support had a significant effect on adoption (Hameed & Counsell, 2012; Jeon et al., 2006).

From the construction perspective, the Malaysian government is now focusing their attention on the traditional methods to the industrialization building system (IBS). The government strongly encourages builders to use the IBS including an interlocking brick system in their housing development projects (KPKT, 2012) as spelled out in IBS Roadmap 2003-2010. The roadmap clearly promotes the IBS implementation as well as guides practitioners and policymakers on related issues (CIDB, 2003). That is, the roadmap strongly indicates the serious efforts of the government in promoting the use of new technologies in the construction industry in its attempt to achieve the target of developing an open building industry by the year 2010 (CIDB, 2003).

In Malaysia, the push-pull factors from the government are responsible for the adoption of the technology such as the LBM system (Hamid, Anuar, & Kamar, 2010). To encourage the use of the LBM system, the government offers training, establishes an information center, and develop an incentive system for the contractors interested in the construction technology. Therefore, potential users such as builders will develop a favorable perspective of the new applications such as LBM building system and are more likely to use them.

3.12.2 Contractor support

A contractor is defined as an organization or person that undertakes a contract to provide materials and/or labor for a construction project (Entrop & Dewulf, 2010). Gould and Joyce (2011) defined contractors as professionals who are responsible for all construction activities, whether they works as a general contractor or a construction manager. The duties of the main contractor and subcontractor begin in the early stages of the construction stage until the handover of the projects. Koebel et al. (2015) suggested that a contractor and subcontractor contribute to the green building adoption.

Contractors influence the adoption of technology (Dikmen et al., 2005). If they have experience with the technology, possess adequate cash flow, and provide good supervision and site management, the effectiveness of the project will be enhanced (Saqib, Farooqui, & Lodi, 2008). Contractors play an intermediary role between the institutions that develop the products and processes and those that adopt the technology (Aouad et al., 2010). In sum, contractor support has a significant role in the adoption of a construction technology, and this factor cannot be neglected in the adoption of the LBM building system.

3.12.3 Supplier support

Manufacturers or suppliers are regarded as the key drivers in the construction industry. According to Larsson, Sundqrist, and Emmitt (2006), suppliers providing the material components and processing equipment to a building project are one of the most neglected areas in research on innovation in the construction sector. Manufacturer or supplier support is important in the construction industry because construction projects require materials and equipment from the manufacturers or suppliers. A shortage of materials will cause a delay in the project, which inevitably increases costs.

According to Manley and Marceau (2002), suppliers are directly engaged in the worksite. They are related to the contractor by offering products, transforming products on site, and integrating the products with other components. The suppliers are connected to clients because they demand for a 'total package' solution and contractor requirements for quality assurance. They spend more on research and development (R&D) as compared to contractors or consultants, and then they adopt the research outcome in the construction project (Manley, 2006). Indeed, several researchers demonstrated that supplier support had a significant influence on the adoption of a technology (Ghobakhloo et al., 2011; Oliveira & Martins, 2010).

3.12.4 The Relationship between External Support and Organization Perceptions

External support is an important determinant of technology adoption. Studies by Al-qirim (2007), Premkumar and Roberts (1999), and Scupola (2009) found a positive role external support played in helping organizations to be more competitive.

In their study, Dikmen et al. (2005) indicated that innovations in the construction industry usually emerged from external factors such as suppliers. Kuan and Chau (2001) and Scupola (2009) showed that government support was an important element in the adoption of technology. Meanwhile, Saqib et al. (2008) argued that the success of a project implementation was due to contractor support. However, TAM proposes that external support will indirectly affect on the adoption through its effects on perceived ease of use (Igbaria et al., 1997). In study by El-gohary (2012) showed a non-significant relationship between external factors and perceptions.

Regarding to the inconsistent results, the relationship between external factors such as government support, supplier support, and contractor support and the adoption of the LBM system through organizational perception should be examined further. The external support may enhance the perceptions of the technology among the organizations that adopt the LBM system. Hence, the following hypothesis was developed as follows:

H3: External support has a significant effect on organization perceptions.

3.13 Facilitating Conditions

Facilitating conditions are defined differently depending on the context. According to Terzis and Economides (2011), facilitating conditions depend on the system and the process or the persons that facilitate the situation. For instance, facilitating conditions could be technical support such as helpdesks and online support services. According to Lu et al., (2008), FC has two dimensions which are technology and resources factors. Technology factors are related to the compatibility issues that may constrain usage while resource factors are things such as time and money. Taylor and Todd (1995a) argued that intention and usage of IT would not be expected when less time and money are available as well as when technical compatibility decreases. In addition to these resources, communication activities and involvement of organizational staff could also be defined as FC (Bueno & Salmeron, 2008).

On a different note, facilitating conditions are viewed as external controls related to the environment (Terry, Gallois, & McCamish, 1993). Behaviour could not be occurring if the environment prevents it or if the facilitating conditions make the behavior difficult (Lu et al*.,* 2008). Facilitating conditions have been identified as more influential factors on innovation adoption (Hung, Ku, & Chang, 2003), and their study on the adoption of WMDS services in China showed that facilitating condition was the critical factors influencing adoption. Policies, regulation, and legal environment are considered the critical aspects of technology adoption (Pudjianto et al., 2011; Zhu, Kraemer, & Xu, 2006). Policy and regulation are important components in the implementation of a technology and for the future growth of the technological system (Duan et al*.,* 2010).

Many organizations decide to adopt a technology because of the benefits they will gain as a result of the imposition of regulation, policy, and industry standards (Abukhazam & Lee, 2010). In construction, many governments have decided to regulate the technology implementation based on economic demand, advantages, and competitiveness (Perente & Prescott, 1994). The new policies and regulations are needed to promote the LBM building system adoption in the construction industry. Zhu and Kraemer (2005) concluded that regulations foster the adoption of technology.

3.13.1 The Relationship between Facilitating Conditions and Organization Perceptions

Several studies found that facilitating conditions affected perceptions (Nan, Xun-hua, & Guo-qing, 2007; Taylor & Todd, 1995a; Terzis & Economides, 2011b; Thompson, Higgins, & Howell, 1994; Venkatesh & Morris, 2000). However, Lu et al., (2008) demonstrated that facilitating conditions did not have any significant impact on perception. In their studies, the participants were not concerned about the importance of facilitating conditions in forming their perceptions on the ease of use of the technology. Due to the inconsistent result of past studies, the construct and the effect of facilitating conditions on perceptions are examined in this study. As facilitating conditions are postulated to play an important role in the adoption of technology, it was hypothesized that:

H4: Facilitating conditions have a significant effect on organization perceptions.

3.14 Organizational Perceptions as a Mediator between Organizational Readiness, External Support, Facilitating Conditions, and Load-bearing Masonry (LBM) Building System Adoption

In the process of getting information, potential adopters develop a certain perception of innovation which mould their decision to adopt a technology. Some studies have examined the influence of technological attributes (i.e., perceived ease of use and relative advantage) on adoption in several industries (El-gohary, 2012; Giovanis et al., 2012).

Empirical evidence suggests that innovation perception can predict innovation behavior in difference between studied and setting (Tornatzky & Klein, 1982). Additionally, there is limited research on how construction decision makers perceive innovation attributes and how perceptions mediate the influence of factors on adoption in the construction industry (Hartmann et al*.,* 2008). For this reason, we proposed organizational perceptions as a mediator between organizational readiness, external support, and facilitating conditions on the LBM building system adoption. This is consistent with the call for the need to study the mediation effect of perception on the relationship between external variables on behavioral adoption (Agarwal & Prasad, 1998; Davis, 1989).

H5: Organizational perceptions mediate the relationship between organizational readiness and load-bearing masonry (LBM) system adoption.

H6: Organizational perceptions mediate the relationship between external support and load-bearing masonry (LBM) system adoption.

H7: Organizational perceptions mediate the relationship between facilitating conditions and load-bearing masonry (LBM) system adoption.

3.15 Developing of the Framework

Following by discussion on the factors influence the adoption of the LBM building system, the steps of framework development was discussed and illustrated in following figure.

3.15.1 The Influence of Organizational Perceptions on the LBM building system Adoption

Despite previous literature highlighted the role of organization perceptions in determined technology adoption such as information technology and information system, little attention has looked into organization perceptions on the LBM system adoption. Only Agrawal et al., (2014) and Hartmann et al., (2008) examined the perceptions of potential adopters as a key influence on the construction technology adoption.

As suggested by (Abdullah, 2009), the organization perceptions such as perceived ease of use and relative advantage potential to influence the adoption of LBM system. Then, this study postulated the organization perceptions have a significant effect on the LBM building system adoption.

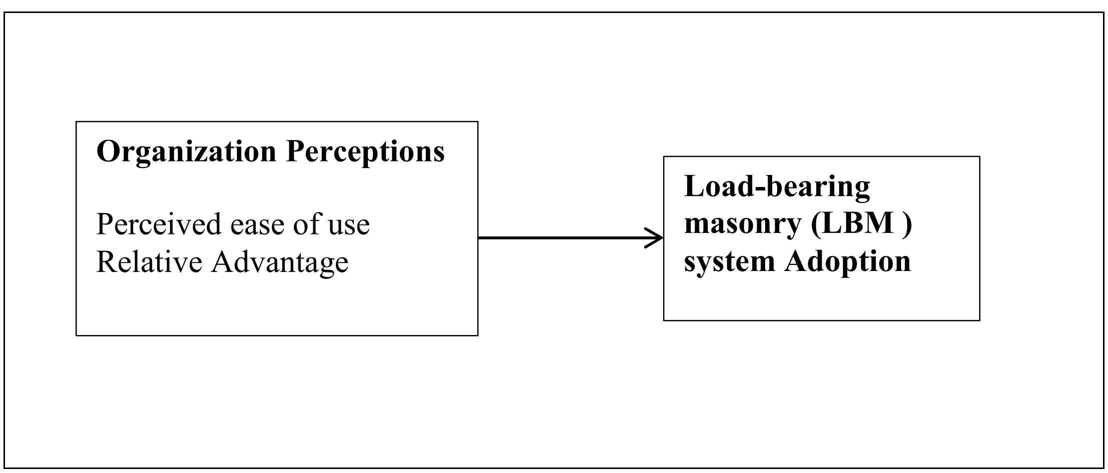


Figure 3.3
The Influence of Organization Perceptions on the LBM building system Adoption

3.15.2 The Influence the of Organization Readiness and Organization Perceptions

Limited studies have examined the antecedents of organizational perceptions on the adoption of construction technology such as LBM building system. Previous research identified the external and internal variables purported to influence perception (Davis, 1989). More studies are needed to corroborate the proposition in different contexts as suggested by (El-Gohary, 2012; Iqbal & El-Gohary, 2014).

Therefore, this study to look at the relationships between factors such as organizational readiness, external factors, and facilitating conditions on the organizational perceptions. Organizational readiness regarding resources such as financial, technology and knowledgeable staff will make firms have a good perception of the technology (Igbaria et al., 1997). Given the considerable interest of researchers in organizational readiness, it is crucial to determine its contribution to the organization's perception in construction technology such as LBM building system. Therefore, this study postulated the organizational readiness has a significant effect on organization perceptions.

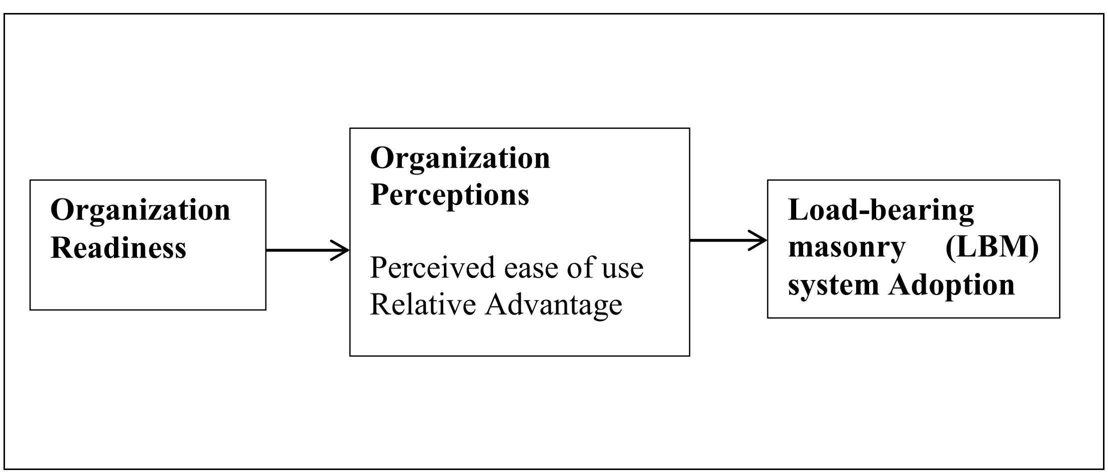


Figure 3.4:

The Influence the of Organization Readiness and Organization Perceptions

3.15.3 The Influence the of External Support and Organization Perceptions

The external support has significant effect on the perceptions (Igbaria et al., 1997). Meanwhile, study by El-gohary (2012) showed a non-significant relationship between external factors and organization perceptions. Regarding to the inconsistent results, the relationship between external support on the organizational perception, it should be examined further. The external support such as government, contractor and supplier may enhance the perception of the technology among the organizations that adopt the LBM system. Then, this study postulated the external support has a significant effect on organization perceptions and Figure 3.5 shows the relationship of the external support and organization perceptions.

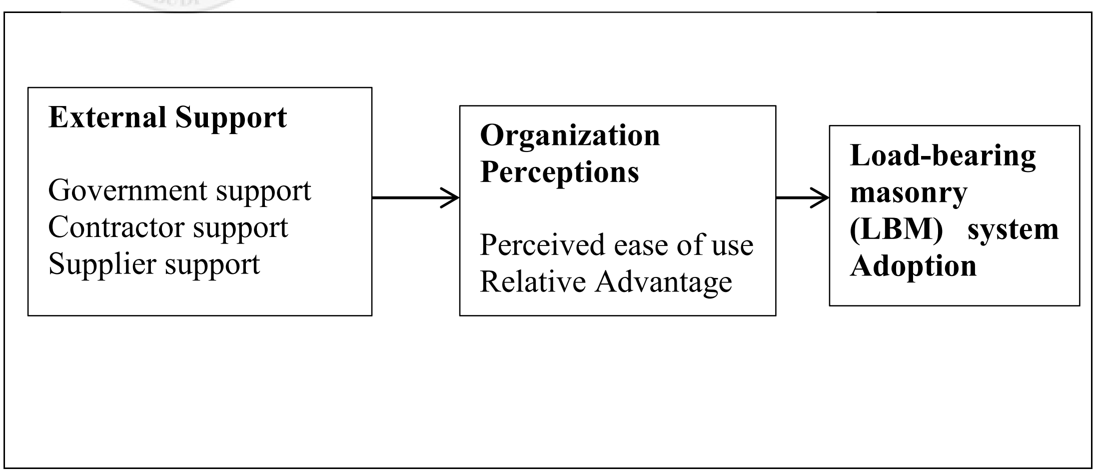


Figure 3.5:
The Influence the of External Support and Organization Perceptions

3.15.4 The Influence of Facilitating Conditions and Organization Perceptions

Several studies found that facilitating conditions affected perceptions on the technology adoption (Nan, Xun-hua, & Guo-qing, 2007; Taylor & Todd, 1995a; Terzis & Economides, 2011b; Thompson, Higgins, & Howell, 1994; Venkatesh & Morris, 2000). Lu et al., (2008) demonstrated that facilitating conditions did not have any significant impact on perception. Due to the inconsistent result of past studies, the construct and the effect of facilitating conditions on perceptions is examined in this study.

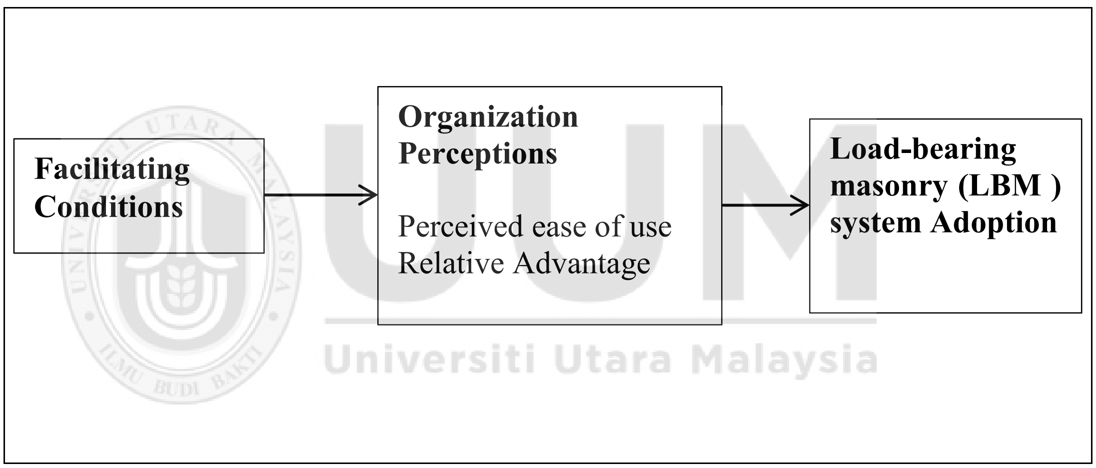


Figure 3.6:
The Influence of Facilitating Conditions and Organization Perceptions

3.15.5 The Mediating Effect of Organization Perceptions between the Organization Readiness, External Support and Facilitating Condition on the LBM building System Adoption

Scholars indicated that research on the determinants of adoption through perception of the construction technology is limited (Hartmann et al., 2008). This study, proposed organizational perceptions as a mediator between organizational readiness, external support, and facilitating conditions on the LBM building system adoption. This is consistent with the call for the need to study the mediation effect of perception on the relationship between external variables on behavioral adoption (Agarwal & Prasad, 1998; Davis, 1989).

3.16 Proposed Framework for Load-bearing (LBM) Building System Adoption

Following the development of a framework above, the proposed framework for the Load-bearing (LBM) Building System was presented in Figure 3.7. The linkages between organization readiness, external supports, facilitating conditions, organizational perceptions, and LBM building system adoption are illustrated in the proposed framework.

The framework has three related parts. The first part connects organizational perceptions and adoption of the LBM building system, which was the dependent variable in this study. The second part links organizational readiness, external factor, and facilitating conditions with organization perceptions. The third part shows organizational perceptions as a mediator between organizational readiness, external factor, facilitating conditions, and load-bearing masonry (LBM) system adoption.

Organizational perceptions were measured by two sub-constructs, namely, perceived ease of use and relative advantages. Meanwhile, external factors were measured by three sub-constructs, i.e., government support, contractor support, and supplier support. The model is based on Technology Acceptance Model (TAM) and Innovation Diffusion Theory (IDT), both of which emphasize technology adoption.

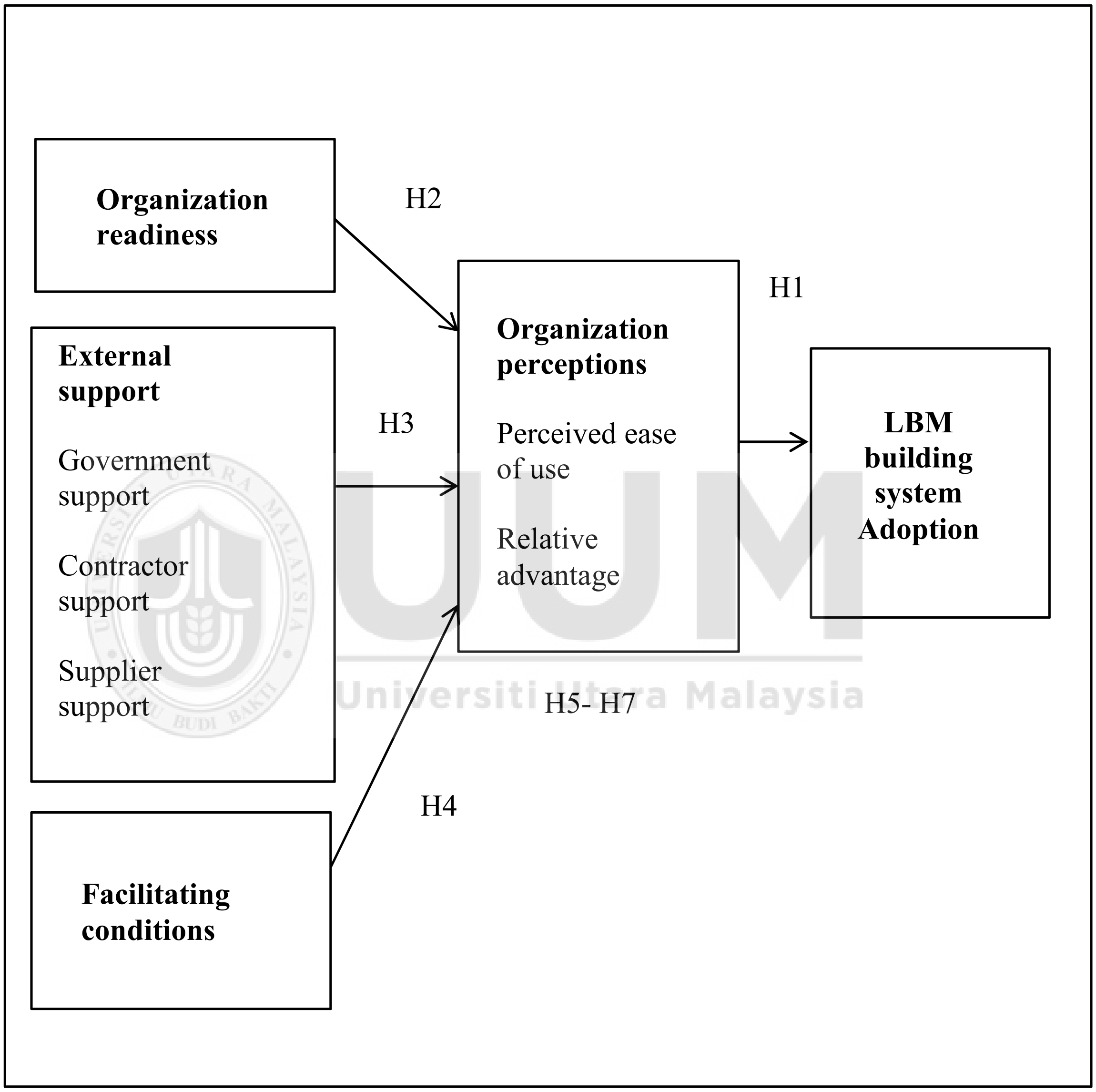


Figure 3.7
Proposed Framework for Load-bearing (LBM) Building System Adoption

Gap of the Literature

A review of the previous literature suggests several gaps in the current body of research in technology adoption in a construction industry. Regarding the variables chosen in this research, namely, organizational perceptions, organization readiness, facilitating conditions, and adoption of LBM building system, the following gaps are identified:

Adopting the LBM building system could resolve some problems in the construction industry, however, research on the factors influencing the adoption at decision stage is limited. Very few studies were conducted on the adoption of the LBM building system (Abdullah et al., 2009; Adedeji, 2008; Agrawal et al., 2014). Other studies tended to look at the perceptions of the industry players on the LBM building system adoption in general without considering specific perceptions such as perceived ease of use and relative advantage. Investigation of these perceptions in the context of construction is scarce even though perceptions have been widely examined in other areas such as information system, supply chain, and information technology.

Previous research such as (Davis, 1989) identified the external and internal variables purported to influence perception. However, more studies are needed to verify the proposition in different contexts (El-Gohary, 2012; Iqbal & El-Gohary, 2014). Therefore, this study postulated that organizational readiness, external factor, and facilitating conditions influence organizational perceptions of the LBM building system.

Scholars, Hartmann et al., (2008) indicated that research on the determinants of adoption through perception in the construction technology is limited. For this reason, this study proposed organizational perceptions as a mediator between organizational readiness, external factor, facilitating conditions, and LBM building system adoption.

Empirical support for combining the TAM and IDT models in a single study is scarce in construction technology studies even though the integration of both models is widely used in other fields such as information system and technology. This study postulated that the combination of TAM and IDT framework could explain the adoption of the LBM building system.

3.18 Summary of the Research Objectives, Research Questions and Research Hypotheses

Table 3.7 summarizes the research questions and objectives that guided the present study. Consistently, several hypotheses statements were developed.

Table 3.7
Summary the Research Questions, Research Objectives and Hypotheses

No.	**Research Questions**	**Research Objectives**	**Hypotheses**
1.	Do organization perceptions influence the adoption of the load-bearing masonry (LBM) building system among the housing developers in Malaysia?	To examine the relationship between organizational perceptions and the adoption of the load-bearing masonry (LBM) building system.	H1; organization perception have a significant effect on the LBM system adoption.
2.	Does organizational readiness influence the organization perceptions of housing developers in Malaysia?	To examine the relationship between organizational readiness and organization perceptions.	H2:Organizational readiness has a significant effect on organization perceptions.
3.	Does external support influence the organzational perceptions of housing developers in Malaysia?	To examine the relationship between external factor and organization perceptions.	H3:External support has a significant effect on organisation perceptions.
4.	Do the facilitating conditions influence organizational perceptions of housing developers in Malaysia?	To examine the relationship between facilitating conditions and organizational perceptions.	H4: Facilitating conditions have a significant effect on organizational perceptions.
5.	Do the organization perceptions mediate the relationship between organizational readiness and load-bearing masonry (LBM) building system adoption among the housing developers in Malaysia?	To examine the mediation of organization perceptions in the relationship between organizational readiness and load-bearing masonry (LBM) building system adoption.	H5: Organization perceptions mediate the relationship between organizational readiness and LBM building system adoption.

6.	Do the organization perceptions mediate the relationship between the external support and LBM building system adoption among the housing developers in Malaysia?	To examine the mediation of organization perceptions in the between external factor and LBM building system adoption.	H6: Organization perceptions mediate the relationship between the external factor and LBM building system adoption.
7.	Do the organization perceptions mediate the relationship between the facilitating conditions LBM building system adoption among the housing developers in Malaysia?	To examine mediation of organization perceptions in the relationship facilitating conditions and LBM building system adoption.	H7: Organization perceptions mediate the relationship between facilitating conditions and LBM building system adoption.

3.19 Summary

This chapter reviewed the literature about the factors influencing the adoption of the technology. The discussion arises with the overview on the construction technology, technology adoption, factors influencing the technology adoption and pervious study on the LBM system. The next section discusses on the related theories such as technology acceptance model (TAM) and innovation diffusion theory (IDT). Then, review of combination and utilizations of the TAM and IDT will be made. The discussions continues with the factors influencing the adoption of the LBM building system such as organization perceptions, organization readiness, external support and facilitating conditions. Based on the discussion of the factor influencing on the adoption of LBM system and related theories, the research hypotheses were postulated. The framework of the study was presented for the LBM building system adoption. Finally, the summary of the research objectives, research questions and hypotheses of this study was presented. Chapter four will discuss the methodology of the study.

CHAPTER FOUR

METHODOLOGY OF STUDY

4.1 Introduction

The chapter describes the methodology used in this study. It begins with an overview of the philosophy of research, followed by the research process and the research method. It then discusses in detail quantitative methods, questionnaire surveys, and other issues concerning the sample frame, sample size, sampling techniques, construct development and research instrument. Finally, the validity of the questionnaire through pre-testing is presented.

4.2 Worldwide of Methodological

Research methodology is a way to solve research problems (Kothari, 2004) systematically. In other words, research methodology talks about the methods or techniques of doing research based on research problems and the logical development of research process. According to Creswell (2014a), research involves three components: philosophy, research design, and research method.

Creswell (2014b) discussed four research philosophies: postpositivism, constructivism, transformative, and pragmatism. Postpositivism (scientific method or doing science research) is concerned about determining probable causes or effects or outcomes. In this philosophy, the researcher identifies and accesses the cause that influences the result by reducing the ideas in a small, discrete set in the form of hypotheses. The assumption of this philosophy is applied in quantitative approach where the researcher describes a relationship between constructs in the form of research questions and hypotheses.

The second philosophy is constructivism (interpretivism), known as a qualitative research approach. In this philosophy, individuals pursue to understand the world in which they live and work. Qualitative researchers use open-ended questions for participants to share their views and opinions. The researcher then interprets the data based on own experiences and background; the process of this philosophy (constructivist) follows the inductive approach.

The third philosophy is transformative; in this philosophy, the research contains an action agenda for changing the lives of participants. Transformative research provides a platform for participants to raise their opinions and agenda to change or improve their life. This philosophy begins with specific issues, creates a political debate, and then changes the issues in society.

The fourth philosophy is pragmatic; it focuses on research problems and uses all available approaches to understanding the problem (Creswell, 2014b). In other words, it is not committed to any system of philosophy and considers a possible approach such as mixed methods (quantitative and qualitative assumptions). The researchers have the freedom to select the methods, techniques, and procedures that best meet their need and purposes.

Additionally, the researchers look at many approaches to collecting and analyzing the data rather using a single method or technique (quantitative or qualitative). The pragmatism philosophy allows researchers to apply any method or assumption and different forms of data collection and analysis of the research.

Given the characteristics of the four research philosophies above, the positivist approach is identified as the most fitting research philosophy for this study. It is because this study identified the relationships of the constructs in form the research questions and proposed hypotheses. Previous chapter, chapter three discussed in detail the factors that influence the adoption of the LBM building system and then hypotheses were developed. In this regard, the relationships between the constructs used to understand the adoption phenomenon.

4.3 Research Process of the Study

This study adapted research process as recommended by Sekaran (2003). Figure 4.1 illustrates the research process of this study comprising background of study, research problem, theoretical framework, hypotheses development, methodology, analysis data, discussions and conclusions.

This study began with the observation of the phenomenon by reviewing previous studies, discussed in the background of the study. Then, based on a thorough literature review, research problems were identified, and seven (7) research questions and seven (7) research objectives were outlined. From the review of the literature, relevant theories were identified which were Technology Acceptance Model (TAM) and Innovation Diffusion Theory (IDT). The TAM and IDT theories and extended with other factors such as organization readiness, external support and facilitating conditions which were used to develop a theoretical framework and hypotheses. For this study, seven (7) hypotheses were developed in examined seven (7) research questions and answered seven (7) research objectives.

The next stage was about determining a suitable research design for the study. First, the relevant techniques of data collection were identified. This study employed a survey method involving the distribution of questionnaires. Before actual questionnaires distribute to the respondents, the validation of questionnaire and pilot study were conducted to ensure all items fully utilized, workable and reliable. The 32 useable questionnaires were collected and analyzed using IBM SPSS version 20.0. The results of the pilot study was showed in Chapter Four. After finalizing all the items through the validation process, the actual questionnaires were sent out using two techniques which are postal mail and electronic mail. A total of 426 questionnaires were distributed to the developer firms in peninsular Malaysia and only 118 useable questionnaires returned for data analysis. The IBM SPSS version 20.0 and SmartPLS version 2.0 were used to analyze the data collected.

The final stage involved the discussions of the data analysis by providing relevant answers to the research objectives. The findings reveal that hypotheses 1,2,3,4,5 and 6 were supported while hypothesis 7 not supported. From the findings, the proposed framework of this study was useful in contributing the understanding of the factors influencing on the LBM building system adoption.

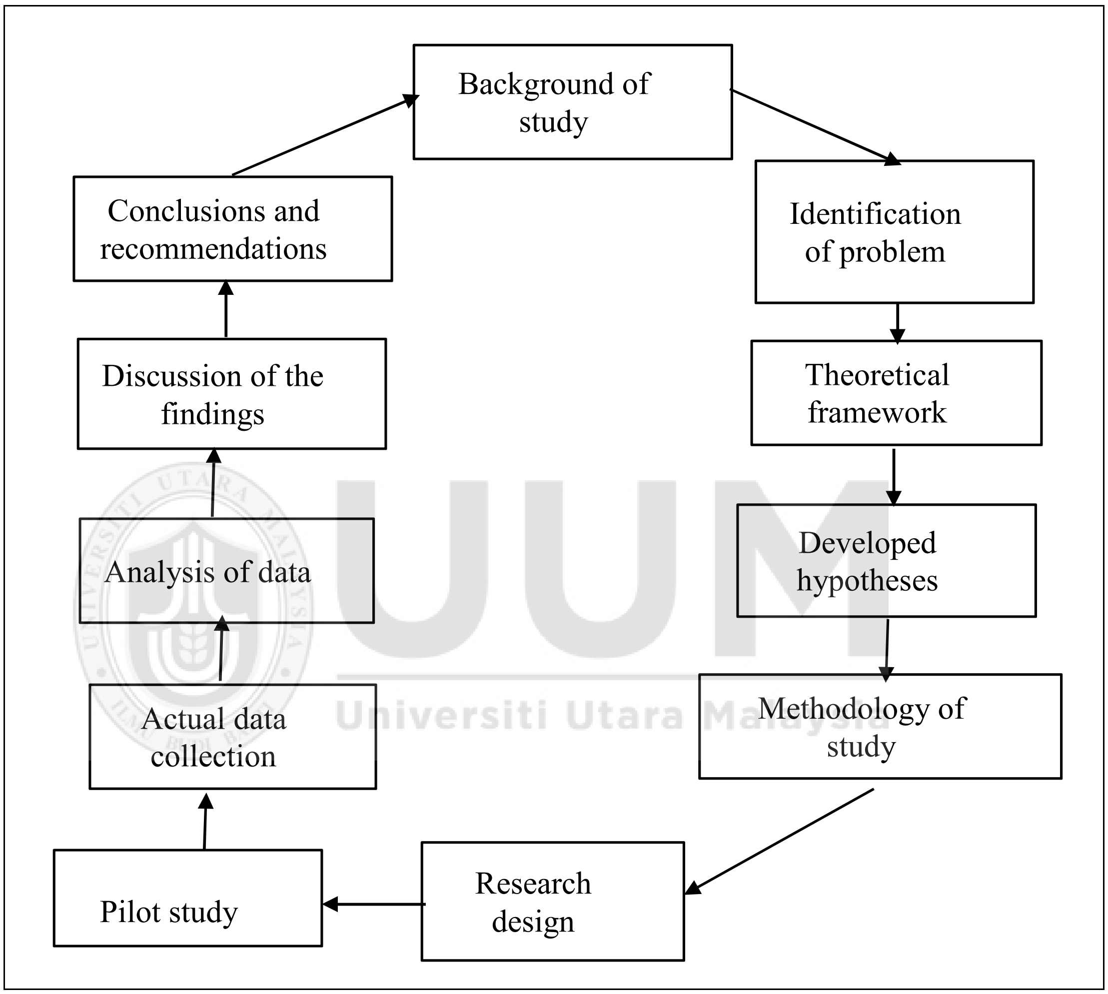


Figure 4.1
The research process

4.4 Research Methods

A research method is defined as the method or technique used for conducting research (Kothari, 2004). Meanwhile, research techniques focus on the behavior and instruments used in performing research operations such as observing, recording data and data processing techniques.

To meet the research questions and research objectives, this study was conducted using a survey-based method. A survey method collects primary data, and the advantage of a survey is that it provides a quick, inexpensive, efficient, and accurate means of measuring information about the population (Zikmund et al., 2013). One of the survey methods is questionnaire survey.

Questionnaires are an effective data collection mechanism when the researcher knows what exactly is required and how to measure the variables of interest (Sekaran, 2000). Questionnaires can be divided into two types according to their administration method: self-administered and interviewer administered. A self-administered questionnaire is described as a survey in which the respondent takes the responsibility for reading and answering the questions (Zikmund et al., 2013). It involves paper questionnaire (mail, directly face to face, attachments, and fax) and/or electronic questionnaire (e-mail, an internet website, and mobile phones). For the purpose of this research, a self-administered questionnaire survey was used for data collection. Self-administered questionnaire survey has advantages regarding less cost and less time (Sekaran, 2000).

4.5 Sampling Frame and Sample Size

Population means the entire group, events or thing of interest that the researcher desires to investigate while a sample is a group or subset of the population (Sekaran & Bougie, 2009). For this study, the population referred to developer firms. The sampling list of the developer firms across Malaysia was obtained from the Real Estate and Housing Developer (REHDA) website. The list contains information such as address, telephone numbers, locations, and website of developer firms. Since the study only focused on developer firms located in Peninsular Malaysia, the population size was is 1,153 registered firms (from REHDA's annual report 2014): 318 firms in the northern region, 470 firms in the central region, 240 firms in the southern region and 125 firms in the eastern region as shown in Table 4.1.

Table 4.1
Number of the Developer Firms in Peninsular Malaysia

Region	**(Developer Firms)**	**Percentage**
Northern Region	318	27.0%
Central Region	470	41.0%
Southern Region	240	21.0%
Eastern Region	125	11.0%
Total	**1,153**	100%

According to Sekaran and Bougie (2009), the sampling frame is a physical representation of the entire element in the population from which the sample is drawn, and it can be worked operationally. Determination of sample size was made following Krejcie and Morgan (1970). In this study the population size was 1,153 and sample size was approximately 285.

This study applied proportionate random sampling method in selecting developer firms. The developer firms were stratified according to their geographical location (regions). The reason for choosing the proportionate stratified sampling technique was to use the same sampling fraction within the strata. It involves identifying subgroups, determining the proportion of the population that corresponds to each subgroup, and randomly selecting the sample from each subgroup. The proportion of sample was matched with the proportion of the population. The overall proportion of sample to population was 25 percent and calculated based on formula by Piaw (2013). The Table 4.2 shows the percentage of proportion calculation.

Table 4.2
Percentage of the Proportion

Descriptions
Percentage of Proportion = sample size /size of population x 100% = 285/ 1153 x 100% = 25%

Stratified random sampling is a useful type of sampling because it offers more information for a given sample size than any other sampling techniques. It separates the population into meaningful parts, and subjects are drawn in proportion to their original numbers in the population (Sekaran & Bougie, 2009).

Even though 285 was the sample size to be considered, this study decided to oversample. This is because of a possible low response rate of around 20 percent, which was common among studies conducted on construction firms (Abu Bakar et al., 2011; Ibrahim, Wira, Shafiei, Said, & Ismail, 2013), Therefore, the number of questionnaires sent out was increased to 50 percent. This method is consistent with Alson and Miller's (2002) study. After factoring a 50-percent increase, the number of questionnaires sent out was 426. Random sampling was used to collect the data for every each region.

The breakdown of the questionnaires sent to developer firm by region was 118 for the northern region, 174 for the center region, 88 for the southern region, and 46 for the eastern region. Table 4.3 shows the distribution.

Table 4.3
The Number of Sample Size for Developer Firms

Region	**Population**	**Proportionate sampling (25%)**	**50% increase of sample size**
Northern Region	318	79	118
Central Region	470	116	174
Southern Region	240	59	88

Eastern Region	125	31	46
Total	**1,153**	**285**	**426**

4.5.1 Unit of Analysis

A unit of analysis refers to units the researcher uses to gather data. It can be individual, group, or organization (Creswell, 2014). It is important to understand the unit of analysis because conclusions of the research depend on it. The unit of analysis for this study was organizational, and only one respondent recognized to represent the firm decision was to answer the questionnaire.

In-house of project teams, comprising as the managers, professional level and executive level were chosen as the respondents to fact they are involved in the operations of the company. The present study recruited these respondents as the sources of data to be in line with previous studies (Yusof et al., 2011). Secondly, these respondents are normally involved in the planning and implementation of the company projects. As such, they are considered key employees in the organization's operation and familiar with the projects. Furthermore, their job is critical to the performance of the construction firm.

4.6 Construct Measurement

This study has five constructs. They are organizational readiness, external support (government, contractor, and supplier support), facilitating conditions, organizational perceptions and adoption of the LBM building system. The items for each construct were adapted from past studies and rephrased to suit the study. In total, 46 items were used to measure the construct. The items and their sources are shown in Table 4.4.

Table 4.4
Item for Measurement of Constructs

Constructs	Number of items	Sources
Organizational readiness	6 items	(Hadaya & Pellerin, 2010; Iacovou et al., 1995; Tsai & Tang, 2012)
Organization perceptions		(Davis, 1989; Majid et al., 2008)
Perceived ease of use	5 items	
Relative advantages	6 items	(Iqbal & El-Gohary, 2014; Majjid et al., 2008; Moore & Benbasat, 1991)
External Support		
Government support		(Premkumar & Roberts, 1999)
Contractor support	5 items	
		(Chan & Kumaraswamy, 1997; Saqib et al., 2008)
Supplier support	7 items	
		Chua et al., 1999; Kog & Loh, 2012)
Facilitating conditions	5 items	
		(Lu et al., 2003; Zhu & Kraemer, 2005)
Adoption of LBM building System	4 items	
		(Majid et al., 2011)

8 items	

4.6.1 Operational of Construct and Design of Instrument

The dependent variable for this study is the adoption of load-bearing masonry building system. Organizational perceptions were proposed as a factor influencing the adoption of load-bearing masonry building system and as a mediator. The independent variables are organizational readiness, external factor, and facilitating conditions.

The questionnaire used to collect data had four sections. Section I had eight questions on demographic information of the respondent as well as categories of LBM building usage. Section II had 11 items measuring organizational perceptions, 17 items measuring external support, four items measuring facilitating conditions, and six items measuring organizational readiness. Section III had eight items measuring load-bearing masonry (LBM) building system adoption. The following discusses each measurement.

4.6.1.1 Organization perceptions

In this study, organizational perceptions referred to the organization's belief in the decision to adopt the LBM building system is influenced by innovation characteristics namely perceived ease of use and relative advantage. Five items measuring perceived ease of use were adapted from Davis (1989) and Majid et al., (2008). Meanwhile, six items for relative advantage was adapted from Iqbal and El-Gohary (2014), Majid et al., (2008), and Moore and Benbasat (1991).

Organizational perceptions were measured using a five-point Likert scale, ranging from 1= strongly disagree to 5= strongly agree. The respondents were asked to rate their organizational perceptions of the LBM building system adoption. Table 4.5 shows the items.

Table 4.5
Items of Organization Perceptions

Dimension	**items**
Perceived ease of use	1.LBM building system is easy to understand
	2.It is easy for our company to get information on LBM building system
	3. It is easy for the workers to become skilful at using LBM building system
	4.Easy for the workers in getting information about LBM building system method
	5. the storage of the material (bricks or blocks) become manageable when implemented the LBM building system at construction site
	6.LBM building system will enhance our housing project efficiency
Relative advantage	7.LBM building system enhance project efficiency
	8. Using LBM building system for the housing project is the way to move forward and more competitive in the construction industry
	9.Using LBM building system will improve our housing projects performance
	10.Using LBM building system in the project enables the our company to accomplish construction works more quickly

	11.Using the LBM building system would make it easier to complete the housing projects
	12.LBM building system is useful for the housing construction projects

4.6.1.2 Organization Readiness

Organizational readiness refers to the availability of the organizational resources to adopt the technology (Hadaya & Pellerin, 2010; Iacovou et al., 1995; Tsai & Tang, 2012). In this study, organizational resources include technology, employees, and finances. Items measured the importance of the organizational resources for the LBM building system adoption on a five-point scale ranging from 1= strongly not important to 5= strongly important. Organizational readiness was evaluated using six items: firm's available finance, technology, software, financial resources for modules or technical documents, management support in the implementation of LBM building system, innovative staff in the practicing of LBM building system, and documented modules or technical documents to gaining mastery in the LBM building system. The six items are shown in Table 4.6.

Table 4.6
Items for Organization Readiness

No.	Items
1.	A firm requires enough financial resources for employees' training
2.	A firm requires a software in designing the LBM building system

3.	A firm requires enough financial resources for modules or technical documents
4.	A firm requires management support in the implementation of LBM building system
5.	A firm requires an innovative staff in the practicing of LBM building system
6.	A firm requires documented modules or technical documents to gaining mastery in the LBM building system.

4.6.1.3 External Factor

External factor/support refers to the availability of third party support for the implementation and use of the LBM system. External support comprised three dimensions, i.e., government support, contractor support, and supplier support. The items to measure government support were adapted from Premkumar and Roberts, 1999). The items to assess contractor support were adapted from Chan and Kumaraswamy (1997) and Saqib et al., (2008) while the items for supplier support were from Chua et al., (1999) and Kog and Loh (2012). All items were measured on a five-point scale, ranging from 1= strongly not important to 5= strongly important. The items are shown in Table 4.7.

Table 4.7
Items for External Support

Dimension	Items
Government Support	1.Incentive from the government for firms that used LBM system
	2.The government market the products (housing) using LBM system

	3.The government promotes the use of the LBM system for housing projects
	4.Government needs to hire the agencies that provide LBM system’s training
	5. Government promote this LBM system by offering free training session
Contractor support	6. Contractor’s experiences in LBM system
	7.Contractor has enough control for site management when using LBM system
	8.Contractor needs to have proper supervision of LBM system
	9.Proper involvement of subcontractor for LMB system
	10.Enough cash flow from the contractor
	11.Contractor needs to have effectiveness of cost control system
	12.Contractor needs to have right in information flow
Supplier support	13.Good turnover rate from the supplier
	14.Supplier needs to have top management supports
	15.capability of supplier’s key personnel
	16.Good of services to supplier and delivery the materials from the supplier
	17. Competency of supplier’s proposed team

4.6.1.4 Facilitating Conditions

Facilitating conditions refer to the external controls related to the policy, regulation standard, purchasing of the software, and available instruction for the adoption of the LBM system. The measure of facilitating conditions was adapted from studies (Lu et al., 2003; Taylor & Todd, 1995b; Zhu & Kraemer, 2005). Four items were used to measure facilitating conditions on a five-point scale, ranging from 1= strongly not important to 5= strongly important. The items are shown in Table 4.8

Table 4.8
Items for Facilitating Conditions

No.	Items
1.	Company policies encourage the implementation of LBM building system for our housing projects
2.	LBM building system required for design regulation standard
3.	Government needs to setting up laws and regulations for supportive LBM building system implementation
4.	Government policies encourage the usage of LBM system in housing development projects

4.6.1.5 Adoption of LBM building system

Davis et al., (1989) suggested that adoption is an essential for technology use. Meanwhile, Fishbein and Ajzen (1975), proposed that the adoption is a measure of the strength of intention to execute a specified behavior. Majid et al., (2011) suggested that the adoption of construction technology is a measure of the technology benefits to the company and construction activities. For measure the adoption of LBM building system, eight items were adapted from Majid et al., (2011). The items were measured on a five-point Likert scale, ranging from 1= strongly disagree to 5= strongly agree. The respondents were asked to rate their intention on the LBM building system adoption for their future projects. Table 4.9 displays the items.

Table 4.9
Items for LBM building system Adoption

No.	Items
1.	LBM building system provide fewer workers at construction site
2.	Reduce wastage at a construction site
3.	Minimize the materials at construction site
4.	Improve the cleaner environment at construction site
5.	Improve the quality of work at construction works
6.	Improve safe environment at construction site
7.	Reduce maintenance works at construction site
8.	Minimizes the total cost of housing projects

4.7 Demographic and Organization Information

Several questions regarding the organization and the respondent were also asked such as the location of the organization, the type of the company, the number of employees, job position, company's experiences in the housing project, the respondent's position and working experience. The respondents were also requested to indicate whether the firm used the LBM system or not and specify the LBM system implementation in their projects.

4.8 Scale of Measurement

The scale of measurement is the response options to the questions that the researcher observes in scale categories. It is important to understand the scale of measurement to assess the quality of the instrument (Creswell, 2014b). In behavioral sciences, the scales used to measure the variables are nominal, ordinal, ratio, and interval.

This study employed closed-ended questions and used nominal and interval scales. The closed questions required the respondents to tick or circle a choice of answers given. Therefore, it is important to construct a set of questions that is capable of capturing the necessary information to address the research questions. Subsequently, in this study a set of questions were developed and divided into three sections as follows:

Section I focuses on the background of the firm such as the location of the firm, the type of the firm, the number of years in business, the annual volume of work, and the number of employees.

Section II presents the factors that influence the adoption of the LBM system, organizational readiness, external support (government, contractor and supplier support), facilitating conditions, and organizational perceptions.

Section III presents the intent to adopt load-bearing masonry (LBM) building system. It also requests comments and suggestions from the respondents on the LBM system in Malaysia.

A five-point Likert scale was used (Likert, 1932). A five-Likert scale is considered a balanced scale because there is an equal number of positive and negative options (Galan-Garsia, Merino, Martirez, & Aguilera, 2014). Respondents were required to indicate the degree of agreement and/or disagreement with each statement given.

4.9 Validation of Questionnaire

Academics and practitioners validated the first draft of the questionnaires. The purpose of validation was to ensure the questionnaire was free from problems related to question construction and to check the content validity of the items before the actual data collection commenced. Content validity refers to how well the items developed to operationalize a construct provide an adequate and representative sample of all the items (Kimberlin & Winterstein, 2008). There is no statistical test involved to determine the effective content of the constructs; content validity usually depends on the judgment of experts.

Following a recommendation by Vogt (2007) for a pre-test, experts from the academia and industry were asked to review the instrument for its readability, structure, and ambiguity. The questionnaires were sent to three academicians from Universiti Utara Malaysia (UUM) and three managers from the housing development industry to assess the layout and the items' readability and to ensure respondents will understand the questions well. The experts were also asked to give their suggestions and comments on the questionnaire.

According to Zikmund et al., (2013), a pre-test involves a small scale of the population whose characteristics are similar to those in the actual study and serve as a guide for the implementation of the actual research. Hair, Money, Samoule, and Page (2007) suggested that a pre-test involves a small number of sample size that ranges from 4 to 30 respondents. In the pre-test, only six respondents were involved.

Overall the respondents had understood the questions but made several suggestions for improvement. Table 4.10 shows the suggestions given and the actions taken to enhance face validity.

Table 4.10
Suggestions and Actions Taken to Enhance Face Validity

No	Suggestions	Actions Taken
1.	Scale of the items should be allocated at the beginning of each page	Changes were made to the layout to make it easy for respondents when answering the questions.
2.	Some of the words were difficult to understand	The wording and sentences were improved.
3.	The term used should be clear and easy to understand	Rewording by using simple words.

4.10 Pilot Study

A pilot study was conducted to collect data from the developer firms. A pilot study in social science research is known as a feasibility study or trial study (Pilot & Hungler, 2001). Thabane et al., (2012) offered a very useful discussion on a pilot study. They stated that a pilot study might have various purposes such as testing the study procedures, validation of items, estimation of the requirement rate and variance estimates for power or sample size calculation. A pilot study must be conducted before the actual instruments are fully utilized for the study and is conducted to ensure that items are workable and reliable. van Teijlingen and Hundley (1998) noted that another reason for conducting a pilot study is to develop and test the adequacy of the research instrument and establish whether the sampling frame and technique are effective.

For this purpose, questionnaire was distributed by mail postage to 80 developer firms located at Peninsular. Randomly technique was applied for this pilot study. The list of developers' address was selected from the REHDA's website. 32 respondents were returned the questionnaires for further analysis using IBM SPSS version 20.0. According to Gay, Mills, & Airasian (2006) a small scale of respondents is applicable for pilot test before conducting actual study. The results of pilot study discusses in chapter five.

4.11 Procedures of Data Collection

After finalizing all the items through the validation process and pilot study, questionnaires were sent out using postal mail and electronic mail. A postal mail survey method was chosen because of the vast geographic location involved. That is, this method allows a large group of respondents to answer the questions within a short period (Sekaran & Bougie, 2009). Also, electronic mail was used because some firms did not have their postal address.

A set of questionnaire along with a cover letter stating the purpose of the study was sent to the targeted respondents.

After two weeks, the questionnaires were distributed again when the respondent failed to reply. Telephone calls were also made to remind the respondents about the survey until an adequate number of responses were received.

4.12 Data Analysis and Hypothesis-testing Procedures

Two types of software were used to analyze the data. For descriptive statistics, the IBM SPSS software version 20.0 was used. Meanwhile, to estimate the measurement and structural models of the study, the Partial Least Squares Path Modeling (PLS), a component-based Structural Equation Model (SEM), was utilized.

4.12.1 Preliminary Analysis

The data analysis involves some steps starting with the coding of data, screening the data, and choosing the right statistical analysis. According to Pallant (2013), the screening process involves two steps: checking for error and finding and correcting an error. Descriptive statistics are run to ensure the data are free from any error. They assess missing data, normality, and outliers.

4.12.2 Handling Missing Data

The first step in the data screening process is identifying missing data. Missing data occurred when respondents omitted from answering questions because they might not understand them (Sekaran, 2003). Various techniques are available to handle missing data either through deletion, distribution or replacement (Coakes, 2012).

4.12.3 Assessing of Normality

According to Hair et al., (2007), normality refers to the shape of the distribution of an individual variable. Skewness and kurtosis are used to assess whether the data are normally distributed. Normality is achieved when the values of skewness and kurtosis are zero.

4.12.4 Outliers

An outlier refers to the considerable differences between the actual and predicted value of observations (Hair et al., 2007). An outlier causes the data distribution to be non-normal, which has an effect on the findings (Coakes, 2012; Hair et al., 2007)

4.12.5 Structural Equation Model (SEM)

Structure equation model (SEM) is a family of statistical models that seeks to describe the causal relationships among multiple variables (Hair, Black, Babin, & Anderson, 2010). That is, SEM establishes a structural model and examines the complicated relationship.

According to Ng, Wong, and Wong (2010), SEM is better than other multivariate techniques including multiple regression, path analysis, and factor analysis in analyzing the cause-effect relations between latent constructs.

In SEM, the latent constructs are measured by observed variables called items or indicators. The items are responses given in a questionnaire. The relationships between the latent constructs and their items or indicators are underpinned by measurement theory (Sarstedt et al., 2014).

Two approaches are available in SEM: covariance-based structure (CB-SEM) (Joreskog, 1978) and partial least squares (PLS-SEM) (Lohmoller, 1989). The objective of CB-SEM is to produce a theoretical covariance matrix without explained variance, and it is used to confirm or reject a theory (Sarstedt et al., 2014). Meanwhile, the objective of PLS-SEM is to explain the variance in the dependent variable (endogenous latent construct), and it is primarily used to develop a theory (Hair et al., 2011).

4.12.6 Partial Least Square path Model (PLS)

PLS-SEM (also called PLS path modeling) is a method to estimate causal relationships in path models that contain latent constructs which are indirectly measured by manifest variables (indicators or items) (Ringle, Sarstedt, & Mooi, 2010). A PLS path model comprises two elements: (a) a structural model (inner model), which displays the relationships between the latent constructs, and (b) a measurement model (outer model), which shows the relationships between the latent construct and manifest variables (Hair et al., 2014).

In PLS, the outer model consists of two types of model: formative and reflective (Diamantopoulos & Siguaw, 2006). A formative measurement model has a cause-effect relationship between the indicator variables and latent index (independent causes), whereas a reflective measurement model involves a path from the latent construct to the indicator or dependent effects (Jarvis, MacKenzie, & Podsakoff, 2003).

PLS-SEM does not need an adequate sample size compared with other statistical techniques (Marcoulides & Chin, 2013). Additionally, it allows for a more advanced model element such as multiple mediations, moderator and higher-order structure (Becker, Klein, & Wetzels, 2012).

PLS-SEM is widely used in business management, marketing, strategic management, information system (Henseler, Ringle, & Sinkovics, 2009). However, it is still new in construction engineering and management (Memon et al., 2013). Thus, this study contributes to construction management research.

In this study, PLS-SEM was used to analyze the data. PLS-SEM was an appropriate data statistical technique because the objective of this study was prediction rather than confirmation of a structural relationship (Hair et al., 2011). Additionally, PLS-SEM was chosen because it is a tool that can help achieve a high level of statistical power with a small sample size. Even though PLS-SEM has no issue with sample size, the larger sample sizes increase the precision (consistency) of PLS-SEM estimators (Hair et al., 2014). It is an appropriate tool for this study because the unit of the analysis is an organization and of the possibility of obtaining a small number of respondents.

4.12.7 Measurement of Partial Least Square

When using PLS-SEM, the terms of the variable used are different. An independent variable is called an exogenous variable but a dependent variable, and a mediating variable is referred to as endogenous variables. In this study, Table 4.10 indicates the corresponding terms used.

A PLS analysis involves assessing two models: measurement model and structural model (Anderson & Gerbing, 1988). To evaluate the measurement model, construct validity is measured by confirmatory factor analysis (CFA). CFA involves determining the measurement items that represent a construct. The analysis assesses the relationship of a construct to a variable by factor loadings and the relationship of the construct to each construct by correlation. The factor loading, variance extracted, discriminant validity, and reliability represent construct validity. Table 4.11 illustrates the acceptable result of CFA.

According to Hair et al., (2011), a Cronbach's α value should be higher than 0.7, but a value of 0.6 is adequate for internal consistency (Sekaran & Bougie, 2009). For composite reliability (CR), a cut-off value more than 0.7 is adequate for internal consistency (Hair et al., 2011). The cut-off value for average variance extracted (AVE) should be higher than

0.5 (Hair et al., 2011). The cut-off for discriminant validity is the square root of AVE that exceeds the inter-correlation of the construct (Chin, 1998b).

Once the measurement model is checked, the structural model is assessed to test the proposed hypotheses. The assessment of a structural model involves calculating the variance explained which is R^2. The R^2 value explains the predictive power of the structural model, which is the value of variance explained by the exogenous variables (Hair et al., 2014). By using bootstrap resampling procedure involving 500 re-sample and 118 cases, the PLS algorithm is calculated to obtain a t value. The observed t value explains the significance of the proposed hypotheses (Hair et al., 2014). The significance level is determined by the t value obtained from the analysis based on the following cut-off value for a two-tailed test: (a) t value > 1.96 ($p < 0.05$), (b) t value > 2.58 ($p < 0.01$), and (c) t value > 3.30 ($p < 0.001$).

Additionally, the effect size (f^2) is calculated to explain the selective endogenous latent construct. In this study, the effect size involves the mediating variables. Specifically, the f^2 explains how the mediating variables contribute to the R^2 value, and it is calculated as follows:

$$\text{Effect size } f^2 = \frac{(R^2 \text{ included} - R^2 \text{ excluded})}{(1 - R^2 \text{ included indicated the effect size } f^2).}$$

Hair et al. (2014) categorizes the effect size f^2 value as 0.02 (small), 0.15 (medium), and 0.35 (large). Next, the predictive relevance (Q^2) of the path model is estimated using the blindfolding procedures. Q^2 is a sample re-use technique (Geisser, 1974) and calculates predictive validity (Hair, Sarstedt, Pieper, & Ringle, 2012). Q^2 presents the combination of cross-validation redundancy for the endogenous construct and is recommended for PLS-SEM assessment (Hair et al., 2014). Predictive relevance is calculated using two methods: cross-validated redundancy and cross-validated communality.

Table 4.11
Exogenous and Endogenous for the Study

Variable	**Variable Measured**	**Dimension**
DV Endogenous	Adoption of LBM building system	
DV Endogenous	Organization perception	Perceived ease of use Relative advantage
IV Exogenous	Organization readiness	
IV Exogenous	External support	Government support Contractor support Supplier support
IV Exogenous	Facilitating conditions	

DV- dependent variable
IV- independent variable

Table 4.12

Acceptable Result for the PLS-SEM Model Analysis

Analysis	**Acceptable Level**	**Reference**
Convergent validity		
Cronbach’s alpha	Cronbach’s α value should be high than 0.7	(Hair et al., 2011)
	But, minimum at 0.6 are adequate value for internal consistency	(Sekaran & Bougie, 2009)
composite reliability (CR)	More than 0.7 to indicate adequate for internal consistency	(Hair et al., 2011)
Average Variance Extracted (AVE)	should be high than 0.5	(Hair et al., 2011)
Discriminant validity	the square root of AVE that exceed inter correlation of the construct and also for the other construct.	(Chin, 1998b).

4.13 Testing Mediating Effect

A mediator is sometimes known as an intervening variable. It explains how an independent variable affects a dependent variable. To test the mediating effect, Baron and Kenny's (1986) approach is widely used. Their method is a causal step approach. The approach requires the researcher to examine each relationship to ensure criteria are met for subsequent analysis. If an independent variable is significantly related to a dependent variable, a total effect is found. The next step is to test the effect of the independent variable on the dependent variable through a mediator variable. If there is no significant between the independent variable and the dependent variable, there is lead to the conclusion that no mediating occur.

According to Hayes (2013) and Rucker et al., (2011), the mediation effect can be observed in the absence of a total effect. Otherwise, in the mediation analysis, the test should concern about the magnitude and significance of the indirect effects.

In assessing the mediator, this study examined the significant indirect effect and the effect size rather than focusing on the significant relationship between an independent variable and the dependent variable before or after controlling the mediator. Figure 4.2 shows a model of assessing the mediator effect in this study.

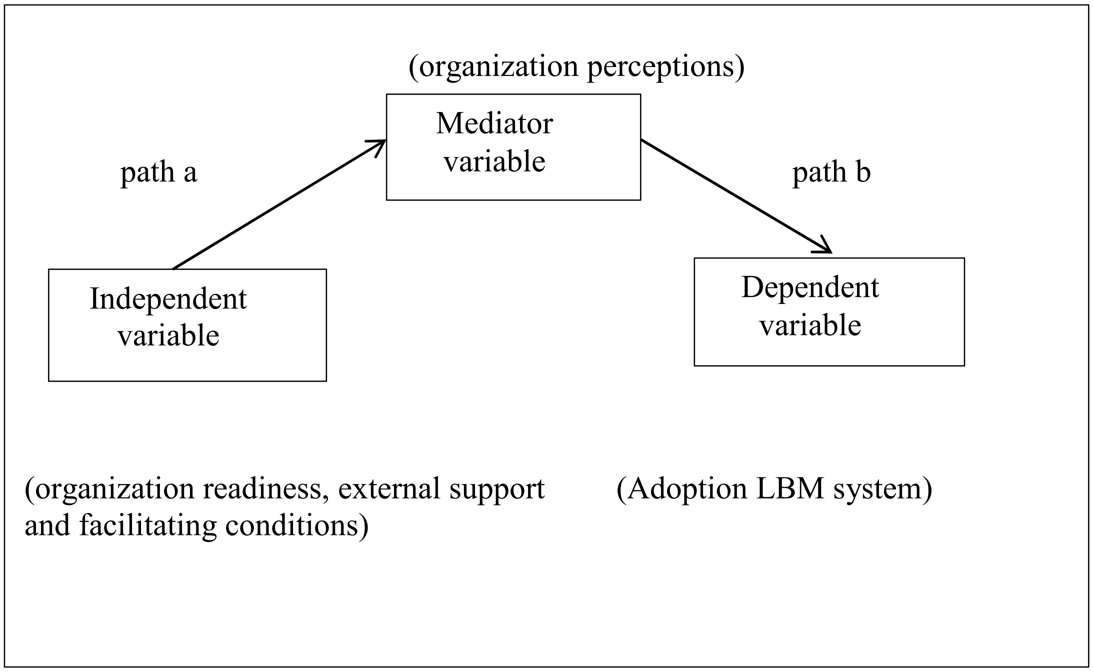


Figure 4.2
The indirect effect of independent variable on the dependent variable with insert of mediator variable

4.14 Summary

This chapter discussed the methodology of the study. It highlighted the research philosophy and research process. Then the research method was discussed in which justification of the quantitative method applying. It also discussed the sampling frame, sample size and sampling technique adopted. Further, this chapter highlighted the measurement and operational of the constructs. Consideration for the pilot study was subsequently highlighted before actual data collected. It also summarized the procedures of data collection and techniques of data analyses to test the hypotheses. Lastly, it explained the steps involved to test mediation study. The next chapter presents the results of the analysis data.

CHAPTER FIVE

DATA ANALYSIS AND RESULTS

5.1 Introduction

This chapter presents the empirical results. As mentioned in the previous chapter, data were analyzed using SmartPLS 2.0. The first part of this chapter presents the result of the pilot test. Then, the demographic profile of the respondents is offered, followed by the assessment of the measurement model. Next, the structural model was evaluated to test the hypotheses. Finally, a summary of the hypotheses testing is provided.

5.2 Pilot Study Results

The pilot study was conducted to assess the reliability of the instruments. Thirty-two respondents completed the questionnaires. The majority of the respondents came from private firms (97.1%) and government-linked companies (2.9%). The majority of the firms were small in size (58.8%) while those from large firms were 18.6% and medium firms 23.5%.

On having experiences in housing projects, the majority of the firms had experienced between 11 and 20 years (44.1%), followed by those with more than 20 years (29.4%), and those with less than ten years (26.5%). Most respondents were at a senior executive level position (41.2%), managerial level (35.3%), and professional level (e.g., engineer, architect) (23.5%).

Most respondents had work experience between 16 and 20 years (47.1%), followed by those with less than ten years of experience (29.4%), 11 and 15 years and those with more than 20 years (11.8% each). Most of the respondents were from the eastern region (44.1%), followed those from the central region (22.4%), and the northern region (26.5%).

Table 5.1

Demographic Profiles for Pilot Study

Characteristics	**No of respondents (n = 32)**	**Percentage (%)**
Type of firm		
Private firm	33	97.1
GLCs	1	2.9
Others		
Number of employees		
Less than 30 employees	20	58.8
31 to 75 employees	8	23.5
76 to 120 employees	6	17.6
Firm experiences		
Less than 10 years		
11 to 20 years		
more than 20 years	9	26.5
	15	44.1
Job position	10	29.4
Managerial level		
Professional level		
Senior Executive level		
	12	35.3
Years of experience	8	23.5
less than 10 years	14	41.2
11 to 15 years		
16 to 20 years		
more than 20 years		
		29.4
Firm location	10	11.8
Northern Region	4	47.1
Centre Region	16	11.8
Eastern Region	4	
		26.5
	9	29.4
	16	44.1
	15	

5.2.1 Reliability Test for Pilot Study

The data collected in the pilot test was analyzed using the Statistical Package for Social Science (SPSS) version 20.0. A reliability test was carried out, and the reliability coefficient score was obtained. Table 5.2 presents the Cronbach's alpha coefficient. The alpha coefficient for organizational perceptions ranged between 0.876 and 0.850, organizational readiness 0.850, external support (government support, contractor support, and supplier support) between 0.601 and 0.858, facilitating conditions 0.843, and the LBM system adoption 0.771.

An alpha value that is greater than 0.60 suggests that the instrument is adequately reliable (Sekaran, 2003). As the alpha values found were greater than 0.60, the instruments were considered reliable and acceptable for future analysis.

Table 5.2
Value of Cronbach's Alpha for Pilot Study (n=32)

Variables	Cronbach's Alpha	No of items
Organization readiness	0.850	6 items
External Supports		
Government supports		
Contractors supports	0.858	5 items
Supplier support	0.832	7 items
	0.601	5 items
Facilitating conditions	0.843	4 items
Organization Perceptions		
Perceived ease of use	0.850	6 items
Relative advantage	0.876	5 items

Adoption Intention of LBM system	0.771	8 items

5.3 Responses Rate

As discussed earlier, the information of the developer firms was obtained from the REHDA website. Questionnaires with personalized cover letters and a support letter from the university were attached, and they were later mailed to the developer firms via postal mail and email. A total of 426 questionnaires were distributed to the developer firms located in peninsular Malaysia, of which 120 questionnaires were returned. Two questionnaires were not usable due to incomplete responses. The remaining questionnaires not returned were considered missing perhaps because the respondents had no knowledge of the LBM building system and were not interested in participating in the study. A response rate of 28% (118/426 x 100) was obtained. The response rate was reasonable because it is approximately similar to previous works. Frohlich (2002) reported a response rate of 32%. Table 5.3 summarizes the responses rate.

Table 5.3
The Responses Rate

Descriptions	**Number**

Number of questionnaires distributed	426
Number of not returned	306
Number of questionnaires returned	120
Number of questionnaires unusable	2
Usable questionnaires	118
Responses rate (%)	28

Since the PLS analysis would be used to analyze the data, 118 cases were deemed adequate since the number met the 10-time rule of the exogenous variables (independent variables). Hair et al., (1998) suggested that a good enough sample size for data analysis is between 100 and 200 respondents.

5.4 Preliminary Checks

The returned questionnaires were checked, coded and entered into a database using the SPSS software version 20.0. Coding is the procedure where the raw data are transformed into symbols (Denscombe, 2010). Coding is usually done in the early stage of quantitative analysis to ensure that the data entry is efficiently done.

Of 120 questionnaires returned, only 118 cases succeeded in the preliminary screening for missing data, normality, non-response bias, and common method bias.

5.4.1 Handling of Missing Data

To treat missing data, a method called exclude list-wise was adopted. The result showed no missing data. Therefore, no data replacement was made, and the study proceeded with the next analysis as indicated in Appendix III.

5.4.2 Data Normality

Normality was examined using the graphical and statistical methods. The result of the descriptive statistics is indicated in Appendix IV, and the normality result in Appendix V.

Data normality means that the values of skewness and kurtosis should be equal to zero, the standard deviation one, and has a symmetric shape curve. The result indicated that the data were not normal because the values of skewness and kurtosis were not equal to zero.

Apart from skewness and kurtosis, the Shapiro-Wilk statistic was also applied to assess the normality of data. If the significance level is greater than 0.5, then the data are normal. The result showed a significance value of 0.00, suggesting that the data were not normal. According to Pallant (2013), data non-normality is quite common in research (Pallant, 2013). However, the normality of data is not required in PLS-SEM analysis. This is because PLS-SEM applies the bootstrapping method in determining the significant relationship for non-normal data. This is among the advantages of using the PLS-SEM method because it does require normality of data (Chin, 1998a).

5.4.3 Detection of outliers

An outlier occurs when a case score is extreme, which can affect the outcome of the analysis (Kumar, Abdul Talib, & Ramayah, 2013). The outlier was identified using a univariate analysis (histogram, box-plots, and standardized of Z score). The detection of an outlier is important because it has an effect on the normality of data (Hair et al., 2010). However, since the PLS-SEM technique would be employed, normal data was not required.

The box-plots technique was used in identifying outliers. No cases were deleted because no extreme points were found outside the boxplots. A serious case of an outlier is indicated by an asterisk (extreme point), and if it happens frequently then the cases need to be deleted (Pallant, 2013). As no outliers were detected, 118 cases were used for the next analysis.

5.4.4 Assessment of Non-Response Bias

To test non-response bias, the differences between early and late respondents are assessed. Since the data were not normally distributed, a non-parametric test was used. The Mann-Whitney U test was applied to test the difference between two independent groups (i.e., early and late respondents) on a continuous measure of a dependent variable. Following Armstrong and Overton (1981), the first batch of questionnaires mailed and returned was classified as early respondents, and the next batch was considered late respondents. The number of the first batch was 48 and the second was 70.

The Mann-Whitney U test result showed that the Z value was -1.262 and p-value were 0.207, which means that there was no difference between the early and late respondents in the decision to adopt (see Appendix VI for the result).

5.4.5 Assessment of Common Method Bias

The next analysis was testing common method bias, which is the key source of measurement error and will influence the validity of the result. The Harman's one-factor test is widely used as a technique to address common method variance. To test the bias, exploratory factor analysis was used (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). The factor analysis will result in a single factor accounting for all covariance. Podsakoff et al. (2003) suggested that common method bias exists in two conditions: (a) a single factor accounts for all the covariance among the items, and (b) a general factor accounts for all the majority of the covariance among the items.

In this study, all items used to measure the independent and dependent variables were entered into a single exploratory factor analysis (see Appendix VII). The result showed 83.04% of the variance, which means that common method bias was not a threat because no single factor emerged, and no one factor accounted for the majority of the covariance among the items.

5.5 Demographic Profiles of Respondents

After the screening test, 118 cases remained for further analysis. Table 5.4 presents the demographic profile of the respondents. The majority of the respondents were from private firms (95%) and only 1% of government-linked companies (GLCs). Close to half of the respondents were from small firms with less than 30 employees (46.6%), followed by those from large firms (15.5%) and medium firms (38.2%).

Regarding experience in housing projects, 39% of the surveyed firms had more than 20 years of experience, followed by those with experience between 11 and 20 years (35.6%), and less than ten years (25.4%). Many respondents had a senior executive position (49.2%), followed by managerial level and professional level (e.g., engineer and architect) (25.4%). Slightly more than half of the respondents had been in their position less than ten years (55.1%) and only 5.1% had more than 20 years of experience.

Only 22 firms used the LBM building system in their projects, and 96 firms did not use the LBM building system even though they had knowledge about it. Many respondents were from the central region (45.8%), followed those from the eastern region (26.3%), the northern region (22.0%), and the southern region (5.9%).

Table 5.4
Demographic Profiles of Respondents

Characteristics	No of Respondents (n=118)	Percentage (%)
Type of Firm		
private firm	112	95.0
GLC	6	5.0
Employees		
less than 30 employees	55	46.6
31 to 75 employees	27	22.9
76 to 120 employees	18	15.3
more than 120	18	15.3
Firm's experience in housing projects		
less than 10 years	30	25.4
11 to 20 years	42	35.6
more than 20 years	46	39.0
Job Position		
Managerial level	30	25.4
Professional level	30	25.4
Senior Executive level	58	49.2
Years of Experience		
less than 10 years	65	55.1
10 to 15 years	26	22.0
16 to 20 years	21	17.8
more than 20 years	6	5.1
Firm's Categories		
Use the LBM system in the projects	22	18.6
non-user but knowledgeable with LBM system	96	81.4
Location		
northern region	26	22.0
centre region	54	45.8
eastern region	31	26.3
southern region	7	5.9

5.5.1 Test for differences between two independent group (Managerial and non-Managerial Level)

Two groups of respondents could be identified: managerial and non-managerial levels. The Mann-Whitney U test was conducted to test whether there was non-response bias in the two groups. The result showed a z-score of -0. 834 at the p-value of 0.403. Since the p-value was greater than 0.05, the two groups were not statistically significant in their responses (see Appendix VI).

5.5.2 Specification of the LBM System in the Construction

Table 5.5 shows the implementation of the LBM system in construction projects. The respondents were asked to indicate whether they used the LBM system in their projects, and only 14.4% reported that they used the system in their housing projects, 3.4% used it for building retaining wall. For frame structure, the firms mixed between the conventional methods (RC frame structure) and the LBM system. Examples of the frame structure using the LBM system are columns, staircases, and beams. However, only 1% used the LBM system in the frame structure.

Table 5.5
Implementation of the LBM system in the Construction

LBM system	Number of LBM usage (22 number of firms)	Percentage (%)
Housing projects	17	14.4
Retaining wall	4	3.4
Frame structure	1	1.0

5.6 Data Analysis and Results

As mentioned earlier, the data collected analysis using PLS-SEM. PLS-SEM was chosen to evaluate the measurement model (outer model) and structural model (inner model) for two reasons. First, PLS-SEM focuses on achieving prediction rather than confirmation of the structural relationship. That is, PLS-SEM aims to maximize the explained variance of the endogenous variables rather than achieve the best fit for the research model. Furthermore, according to Fornell and Cha (1994), PLS-SEM accommodates both reflective and formative constructs. Table 5.6 shows the type of measurement constructs in the study.

Second, PLS is appropriate when the research model has not been tested extensively (Teo, Wei, & Benbasat, 2003). Reviews of literature indicate that the empirical test on construction technology adoption is still low. Thus, this is an opportunity to test the research model comprehensively, and PLS is an appropriate technique for this study.

This study followed a two-stage model: first, developing the measurement model, and, second, testing the structural model as suggested by Anderson and Gerbing (1988). Additionally, the bootstrapping method was applied to examine the significance level for the loading, weight, and path coefficients (Chin, 1998a).

Table 5.6
Sources of Measurement Construct

Constructs	**Type**	**Sources**
Adoption Intention	Reflective	(Chwelos et al., 2001; Igbaria et al., 1997)
Organisational readiness	Reflective	(Iacovou et al., 1995; Tsai & Tang, 2012)
External support	Reflective	(Igbaria et al., 1997; Tsai & Tang, 2012)
Facilitating conditions	Reflective	(Z Nan, Xun-hua, & Guo-qing, 2007; Terzis & Economides, 2011b)

5.6.1 Measurement Model

The data analysis began with the evaluation of the measurement model. The assessment of the measurement model (outer model) is to verify the reliability and validity of the constructs (Hulland, 1999). It determines how well the indicators load on the theoretically defined construct. The analysis would show the loading for the items on the proposed construct. For this purpose, confirmatory factor analysis (CFA) was used. Unlike exploratory factor analysis (EFA), CFA explores the data and provides information about how many factors need to represent the constructs (Hair et al., 2010). CFA tests how well the measured variable logically presents the construct (Hair et al., 2010). In other words, the analysis involved examining the validity and reliability of the model. The results of convergent validity, discriminant validity, and reliability are presented in the next section.

5.6.1.1 Convergent validity

Convergent validity can be determined by calculating item reliability. Items with a loading of less than 0.4 should be dropped (Hulland, 1999) and average variance extracted (AVE)- should be higher than 0.5 (Hair et al., 2011).

Table 5.7 shows that the loading was acceptable for the cut-off point of 0.5. There were five items for adoption, five items for external support, three items for facilitating conditions, and three items for perceived ease of use. Meanwhile, for relative advantage and organizational readiness, no items were deleted because the loadings were over the cut-off point of 0.5.

In the case of average variance extracted (AVE), the items that had values exceeding 0.5 were retained (Hair, Ringle, & Sarstedt, 2012). As shown, up to 50% of the variance in the construct was due to its indicators.

Table 5.7
Convergent Validity

Constructs	Items	Loading	AVE	Composite Reliability	Cronbach Alpha
Adoption	DECISION4	0.620	0.509	0.837	0.756
	DECISION5	0.760			
	DECISION6	0.744			
	DECISION7	0.802			
	DECISION8	0.623			
External Support	CONT3	0.583	0.505	0.833	0.749
	CONT4	0.573			
	GOV1	0.718			
	GOV3	0.849			
	GOV4	0.786			

Facilitating Conditions					
	FC2	0.785	0.774	0.910	0.857
	FC3	0.918			
	FC4	0.928			
Organizational Readiness					
	OR1	0.801	0.5203	0.864	0.810
	OR2	0.824			
	OR3	0.758			
	OR4	0.531			
	OR5	0.667			
	OR6	0.704			
Perceived Ease of Use	PEOU1	0.939	0.809	0.927	0.880
	PEOU2	0.924			
	PEOU3	0.831			

Relative Advantages	RA1	0.799	0.6475	0.901	0.861
	RA2	0.825			
	RA3	0.875			
	RA4	0.843			
	RA5	0.662			

5.6.2.2 Discriminant validity

Discriminant validity is defined as to which construct is different from another construct (Hulland, 1999). It is examined by comparing the AVE of a construct on itself and other constructs. The AVE itself should be higher than the variance shared with others (Chin, 1998b). The square root of the AVE must be greater than the correlation between the constructs.

The research model consisted of a reflective measure. Two approaches were applied to test this model. They were Fornell-Larcker's criteria and cross-loading. The AVE of the latent variable should be higher than itself and the variance shared with others (Fornell & Larcker, 1981). Table 5.7 shows that the highest square root of AVE was 0.899 (PEOU) and the lowest was 0.719 (external support).

The second approach focuses on the loading for each construct. It examines whether the items load higher on their own constructs and low on other constructs. Both of these meet the successful criteria, demonstrating discriminant validity.

Table 5.8
Discriminant Validity

	Adoption	External support	Facilitating Condition	Organization readiness	Perceived ease of use	Relative advantage
adoption	**0.714**					
External support	0.525	**0.710**				
Facilitating conditions	-0.064	0.118	**0.880**			
Organization readiness	0.214	0.518	0.043	**0.721**		
Perceived ease of use	0.017	0.271	0.185	0.834	**0.899**	
Relative advantage	0.413	0.678	-0.132	0.750	0.534	**0.804**

Table 5.9
Loading and Cross Loading

	Adoption	ES	FC	OR	PEOU	RA
CONT3	0.103433	0.583510	0.004713	0.290035	0.220554	0.432928
CONT4	0.204178	0.573248	0.278782	0.312900	0.201548	0.283394
DECISION4	0.620366	0.415709	0.030239	0.384539	0.293067	0.366944
DECISION5	0.760091	0.403528	-0.232494	-0.077632	-0.245598	0.200212
DECISION6	0.744310	0.396410	0.131261	0.316456	0.169967	0.416374
DECISION7	0.802440	0.397213	-0.048782	0.160730	0.013350	0.304529
DECISION8	0.623725	0.267596	-0.104222	0.031313	-0.106695	0.199268
FC2	-0.012203	0.223094	0.785604	0.159747	0.171391	-0.000792
FC3	-0.057880	0.031321	0.918810	-0.119468	0.034895	-0.254479
FC4	-0.081713	0.091838	0.928036	0.079973	0.251118	-0.088206
GOV1	0.312093	0.718849	0.179061	0.428628	0.191872	0.558968
GOV3	0.618510	0.849942	0.184069	0.375557	0.188001	0.542350
GOV4	0.543237	0.786925	-0.166624	0.417873	0.178046	0.525109

OR1	-0.066112	0.192799	0.198312	0.801189	0.855182	0.367423
OR2	-0.004709	0.333182	0.234286	0.824800	0.832035	0.458569
OR3	0.199127	0.214699	0.063320	0.758809	0.737105	0.496953
OR4	0.458070	0.581454	-0.191379	0.531033	0.263668	0.697851
OR5	0.082802	0.454039	-0.028085	0.667465	0.405662	0.541624
OR6	0.349396	0.575785	-0.192994	0.704766	0.376498	0.770625
PEOU1	-0.091315	0.178594	0.206437	0.752804	0.939225	0.406376
PEOU2	-0.025712	0.323904	0.251303	0.769937	0.924549	0.494094
PEOU3	0.177563	0.229935	0.032395	0.730907	0.831997	0.547449
RA1	0.290079	0.618175	-0.210046	0.640512	0.497016	0.799645
RA2	0.371463	0.587020	-0.134593	0.681600	0.434806	0.825011
RA3	0.323044	0.553969	-0.032022	0.657188	0.451703	0.875913
RA4	0.400640	0.464943	-0.032210	0.621328	0.527333	0.843887
RA5	0.273932	0.494935	-0.120451	0.362205	0.184330	0.662145

5.6.1.3 Reliability Test

Reliability is the degree to which the observed variable measures the true value and is error free; thus, it is opposite of a measurement error (Hair et al., 2010). Meanwhile, according to Remler and Ryzin (2015), reliability refers to the consistency of the measurement, and it is directly related to the concept of random error. Reliability is examined via composite and internal consistency (Cronbach's alpha). Values between 0.6 to 0.70 are considered acceptable whereas values between 0.70 and 0.95 are considered satisfactory to good (Hair et al., 2014). In general, the cut-off value for composite reliability (CR) is 0.7 (Hair et al., 2011). From the analysis, all the values of CR exceeded 0.7.

Internal consistency is an estimate of the equivalence of the items from the same test (Kimberlin & Winterstein, 2008). Internal consistency is measured by calculating the Cronbach's alpha. A Cronbach's alpha takes a value ranging from 0 (measures that are totally inconsistent) to 1 (items correlate perfectly). Many researchers agree that a value of 0.5 or less indicate an unacceptable scale and some have stated that a value of 0.6 is required (Liu & Arnett, 2000). However, Hair et al. (2010) stated that the value should be at least 0.7. Table 5.7 shows all values of Cronbach's alpha were greater than 0.7, demonstrating that all the constructs achieved the level of acceptable reliability.

5.6.2 The Structural Model

For structural model, the latent variables were measured by observed all items of the variables for the proposed framework (Figure 5.1). For this study, dependent variable which is LBM building system was measured using eight (8) items, the independent variables which are organization perception, organization readiness, external support and facilitating conditions were measured using thirty eight (38) items. After analyzing the data with involved items deleted, the remaining items for dependent variables were five (5) and remaining items for independent variables were twenty two (22) (Figure 5.2).

Additionally, the structural model is assessed by examining the squared multiple correlations (R^2), predictive relevance (Q^2), and path coefficient. The R^2 shows the variance of all endogenous constructs that explain the exogenous variable (Hair et al., 2014). Predictive relevance (Q^2) (blindfolding) shows the predictive accuracy of the model (Rigdon, 2012; Sarstedt et al., 2014). Meanwhile, the strength and significance of the hypothesized relationships are assessed by the path coefficient (Chin, 1998b).

The relationship was statistically tested to answer research question no.1 to research question no. 4. Table 5.8 indicated that all relationships were significant. The results are discussed in the next section.

Perceived ease of use and relative advantage had a direct and significant relationship with adoption. Both explained 23% of the variance in adoption (R^2= 0.23). Organizational readiness, external support, and facilitating condition had a direct and significant effect on perceived ease of use with 76.2% of the variance explained (R^2= 0.76). Organizational readiness, external support, and facilitating conditions explained significantly 71.8% of the total variance in relative advantage (R^2= 0.718).

The predictive power of R^2 is classified into three categories based on certain cut-off values. If the cut-off value is 0.26, the predictive power is considered substantial, 0.13 moderate, and 0.02 weak (Cohen, 1998). The predictor power of R^2 for organizational perceptions (perceived ease of use and relative advantage) was substantial. The predictor power of R^2 for LBM system adoption was substantial.

Table 5.10

Result for Direct Effects

Relationship	**B value**	**t value**	**Results**
PEOU – LBM system Adoption	-0.284	1.922	Significant
RA – LBM system Adoption	0.565	6.180	Significant
Organization readiness - PEOU	0.954	18.157	Significant
Organization readiness – RA	0.539	10.232	Significant
External supports – PEOU	0.244	3.937	Significant
External supports – RA	0.422	7.290	Significant
Facilitating conditions – PEOU	0.173	2.675	Significant
Facilitating conditions - RA	-0.205	3.611	significant

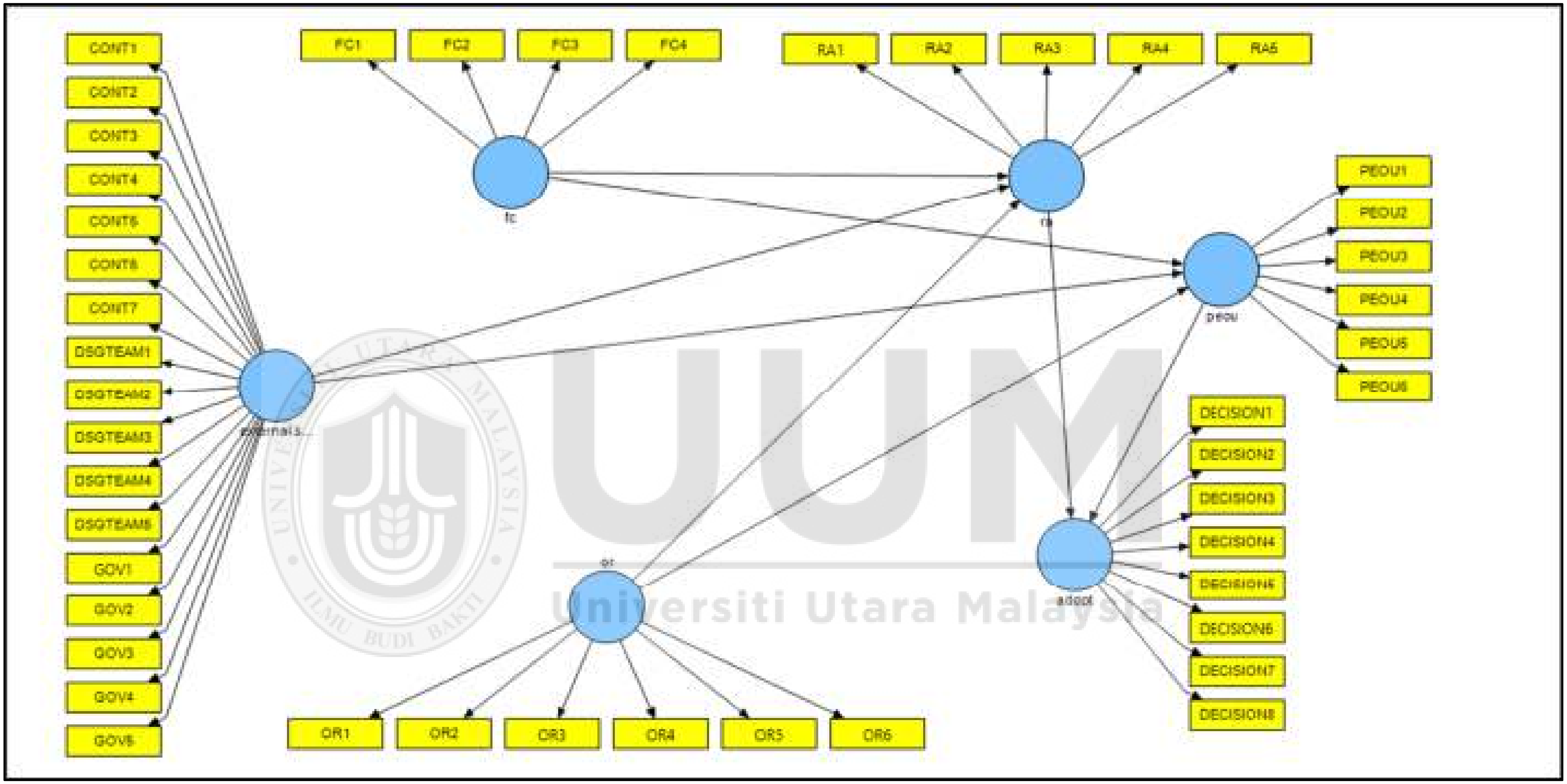


Figure 5.1
Structure Model (Proposed framework)

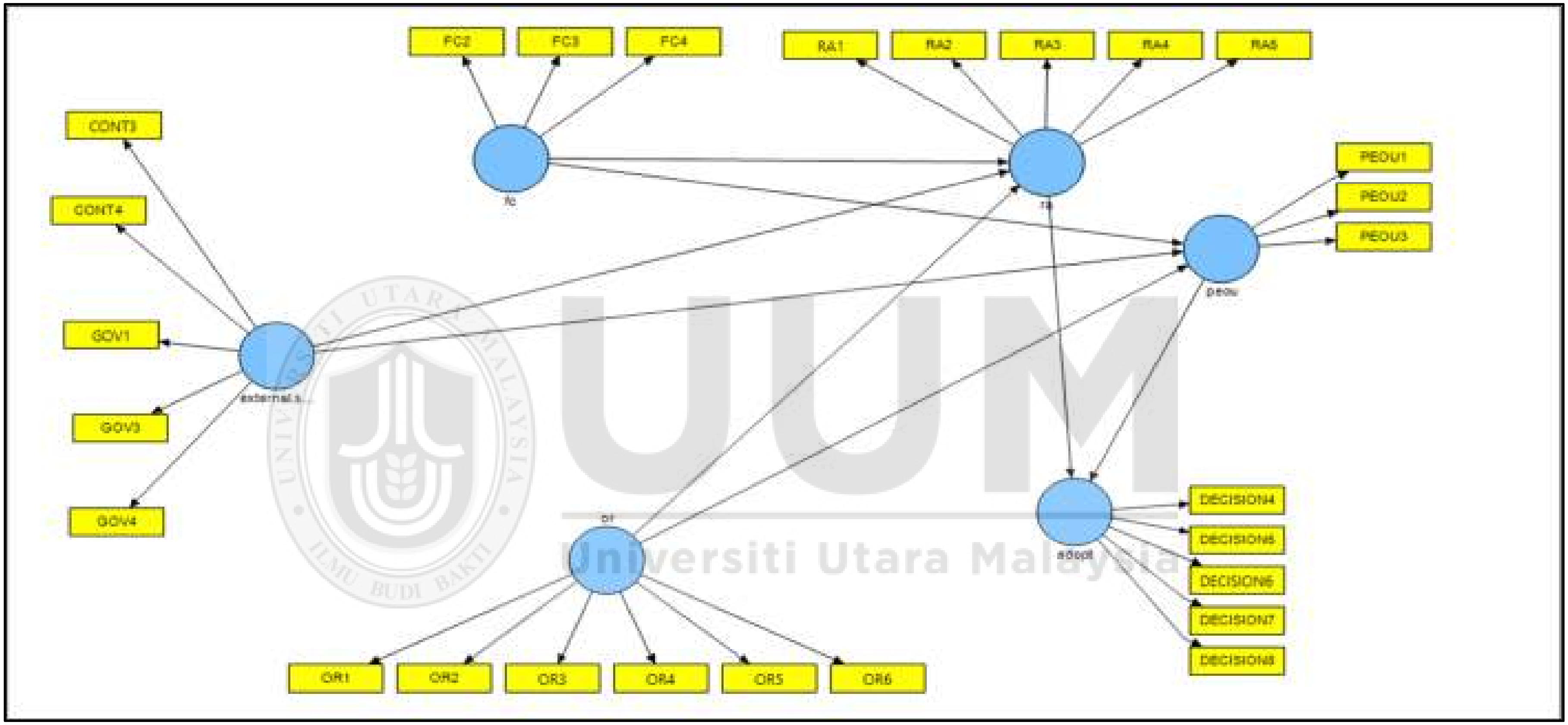


Figure 5.2

Structure model after items deleted (Proposed Framework)

5.7 Test for Mediator

The research framework of this study consists of a mediator variable (organizational perceptions). It was hypothesized that organizational perceptions mediate the relationship between organizational readiness, external support, and facilitating condition and the LBM building adoption. Several scholars (Hayes, 2013; Rucker et al., 2011) stated that significance of the indirect effect could be observed in the absence of a significant total effect. Following their studies, this study applied bootstrapping to generate the sampling distribution of the individual effect.

Unlike Sobel test, bootstrapping does not require normal distribution, which is consistent with the PLS-SEM method. The bootstrapping approach was applied to 500 samples and 118 cases. Twelve paths of the latent variables in this model are depicted in Figure 5.3.

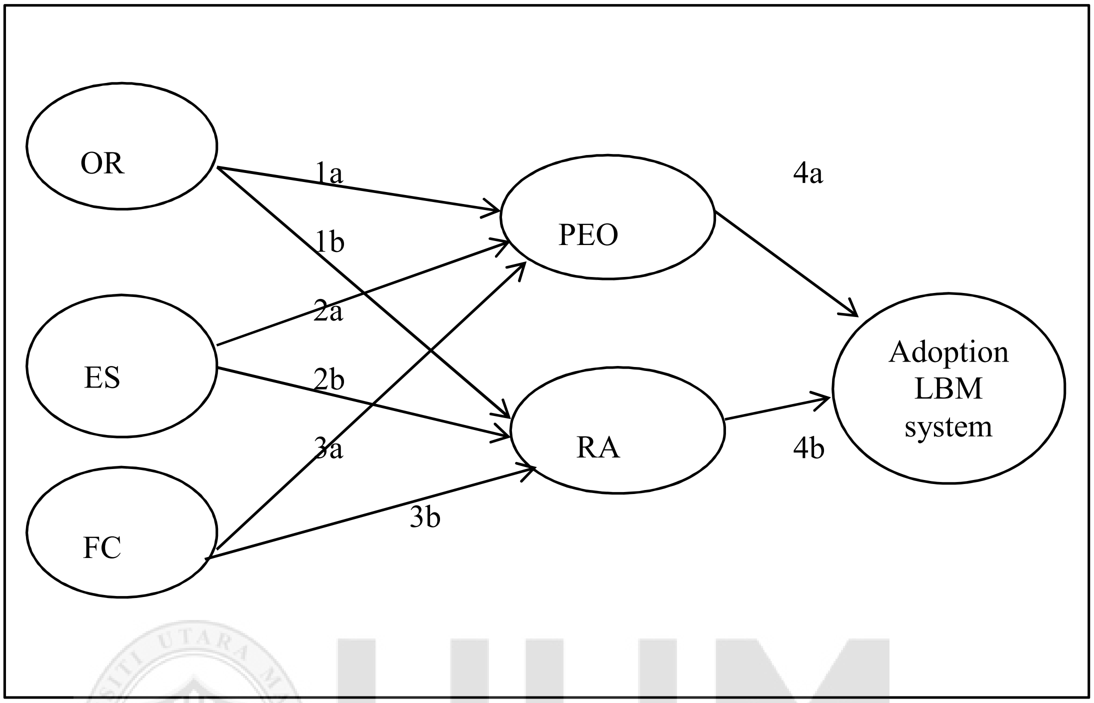


Figure 5.3
The paths of latent variables for proposed framework

5.7.1 Mediation of Organizational Perceptions in the Link between Organizational Readiness, External Support, Facilitating Conditions and Load-Bearing Masonry (LBM) System Adoption

Organizational perceptions were measured by perceived ease of use and relative advantage. The results of the mediation analysis are discussed in the following section, and Table 5.10 summarizes the results.

5.7.2 Mediation of Perceived Ease of Use (PEOU) in Organizational Readiness (OR) and LBM System Adoption Link

The first path in hypothesis 1 (H1a) postulated that organization readiness has a significant effect on perceived ease of use. The second path in hypothesis 4 (H4a) postulated that perceived ease of use has a significant effect on relative advantage. The result for the first path demonstrated a coefficient of 0.954.

The second path analyzed was between PEOU and LBM system adoption. The result indicated a coefficient of - 0.284. Therefore, the indirect effect was 0.954 X -0.284 = - 0.270. The t value for the mediating effect was - 2.057. The result implies that perceived ease of use did not mediate between organizational readiness and LBM adoption. Figure 5.4 shows the result.

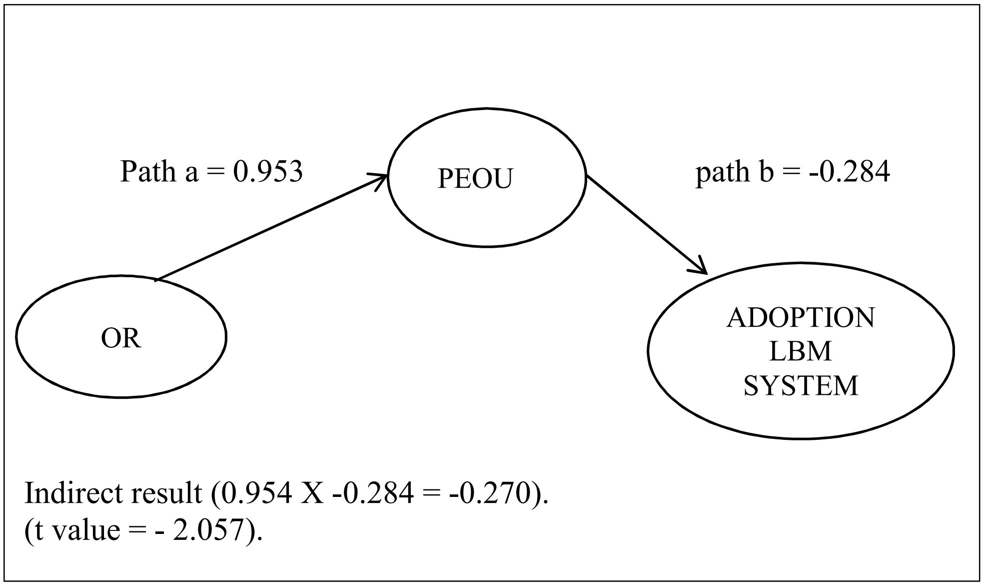


Figure 5.4
Analysis of the mediating effect of PEOU on OR and LBM system adoption

5.7.3 Mediation of Relative Advantage (RA) in Organizational Readiness and LBM System Adoption Link

The first path of hypothesis 1 (H1b) postulated that organization readiness has a significant effect on relative advantage. The second path of hypothesis 4(H4b) postulated that relative advantage has a significant effect on LBM adoption. The result showed a coefficient of 0.540 for the path between organizational readiness and relative advantage and the second path between relative advantage and LBM adoption with a coefficient of 0.566. Therefore, the indirect effect was 0.540 x 0.566 = 0.305). The t value for the mediating effect was 4.048 at $p < 0.01$. The result suggests that relative advantage mediated between organizational readiness and LBM system adoption. Figure 5.5 shows the result.

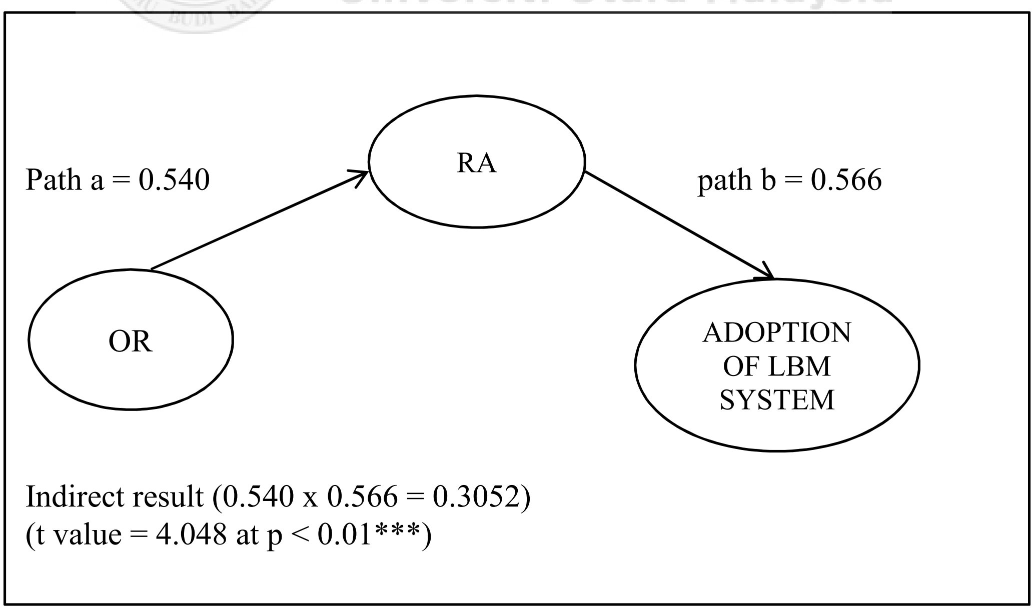


Figure 5.5
Analysis of the mediating effect of RA on OR and LBM system adoption

5.7.4 Mediation of Perceived Ease of Use in External Support (ES) and LBM System Adoption Link

The first path in hypothesis 2 (H2a) proposed that external support has a significant effect on perceived ease of use. The second path in hypothesis 4 (H4a) proposed that perceived ease of use has a significant effect on the LBM system adoption. The result showed that the path coefficient between external support and perceived ease of use was -0.244. The path coefficient between perceived ease of use and LBM system adoption was -0.284. The value of the indirect effect was -0.244 x -0.284 = 0.0693 and the t value was 2.011 at $p < 0.05$. The result suggests that perceived ease of use mediated between external support and LBM system adoption. Figure 5.6 shows the result.

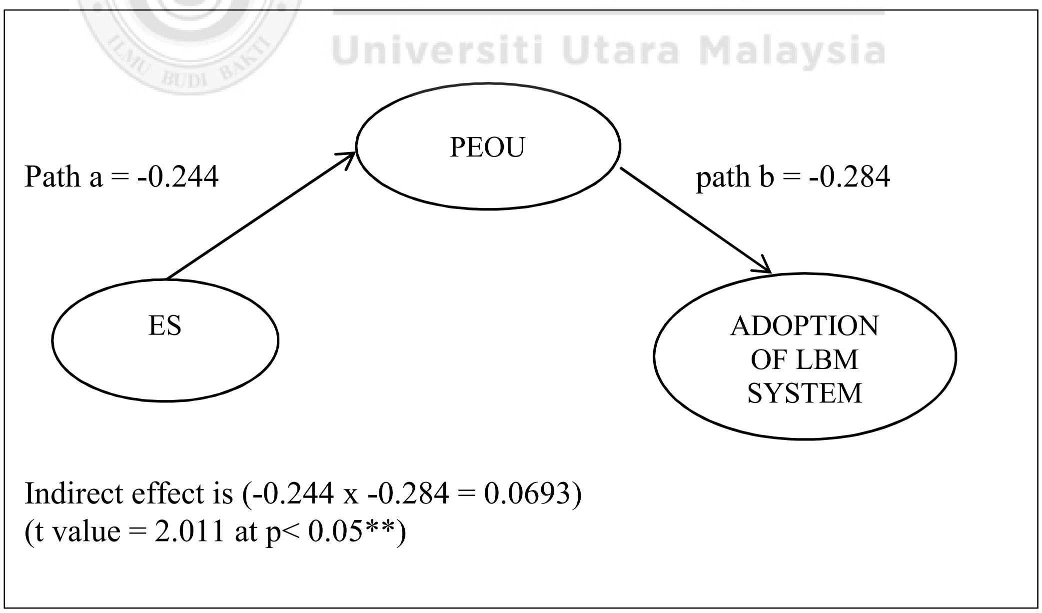
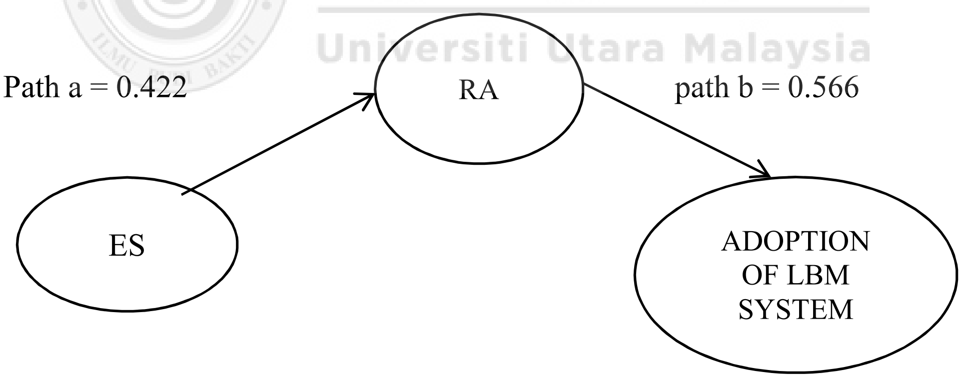


Figure 5.6
Analysis of mediation effect of PEOU on ES and LBM system adoption

5.7.5 Mediation of Relative Advantage in External Support and LBM System Adoption Link

The first path in hypothesis 2 (H2b) proposed that external support has a significant effect on relative advantage. The second path in hypothesis 4 (H4b) proposed that relative advantage has a significant effect on LBM system adoption. The result showed that the path coefficient between external support and RA was 0.422. The path coefficient between RA and LBM system adoption was 0.565. The indirect effect was 0.422 x 0.565 mediated between external support and LBM system adoption. Figure 5.7 shows the result.



Indirect effect is (0.422 x 0.565 = 0.239)
(t-value = 4.967 at p<0.01***)

Figure 5.7
Analysis of mediation effect of RA on ES and LBM system adoption

5.7.6 Mediation of Perceived Ease of Use in Facilitating Conditions (FC) and LBM System Adoption

The first path in hypothesis 3 (H3a) proposed that facilitating conditions have a significant effect on perceived ease of use. The second path in hypothesis 4 (H4b) proposed that perceived ease of use has a significant effect on LBM system adoption. The result showed that the path coefficient between facilitating conditions path coefficient between perceived ease of use and LBM system adoption was -0.284. The indirect effect was 0.173 x -0.284 = -0.0492 and the t value was -2.895 at $p > 0.05$. Therefore, PEOU did not mediate between facilitating conditions and LBM system adoption. Figure 5.8 shows the result.

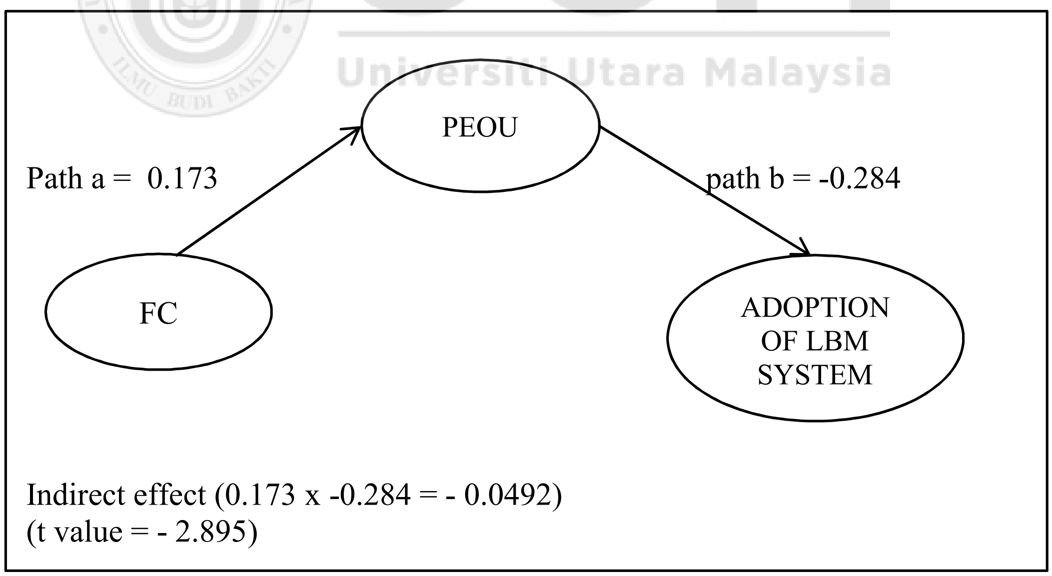


Figure 5.8
Analysis of mediation effect of PEOU on FC and LBM system adoption

5.7.7 Mediation of Relative Advantage in Facilitating Conditions and LBM System Adoption Link

The first path in hypothesis 3 (H3b) proposed that facilitating conditions have a significant effect on relative advantage. The second path in hypothesis 4 (H4b) proposed that relative advantage has a significant effect on LBM system adoption. The result showed that the path coefficient between facilitating conditions and RA was -0.205. The path coefficient between RA and LBM system adoption was 0.566. The indirect effect was -0.205 x 0.566 = -0.116 and the t value was -6.108 at $p > 0.05$. Therefore, RA did not mediate between external facilitating conditions and LBM system adoption. Figure 5.9 shows the result.

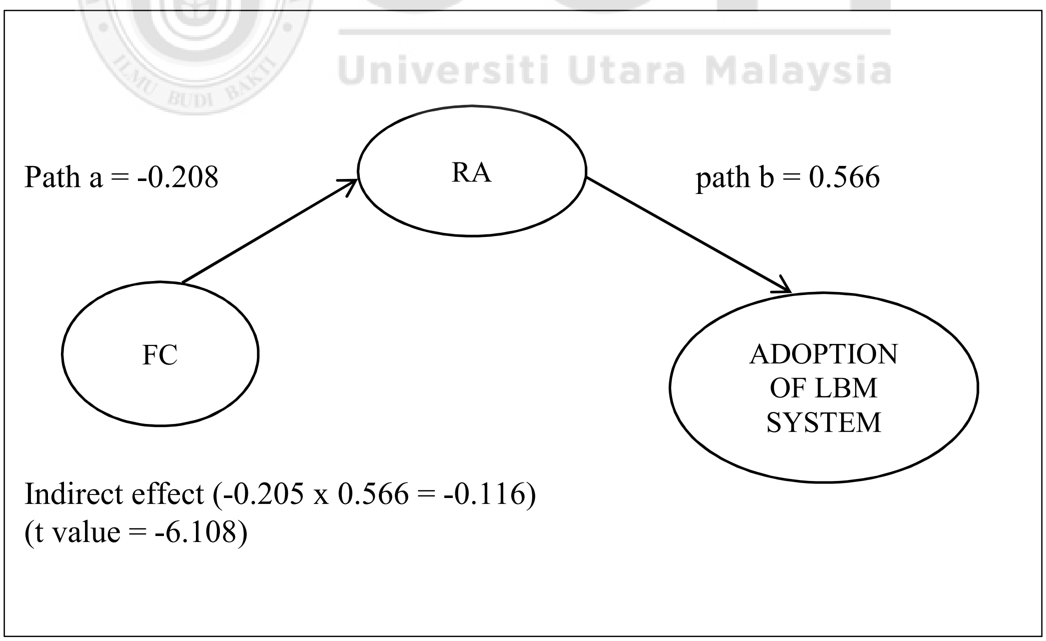


Figure 5.9
Analysis of mediation effect of RA on FC and LBM system adoption

Table 5.11

Results Mediator Effect

Variables	β value	t value	Results
OR> PEOU> ADOPTION OF LBM SYSTEM	0.954	-2.057	No mediation effect
OR> RA> ADOPTION OF LBM SYSTEM	0.539	4.048	Mediation effect
ES>PEOU>ADOPTION OF LBM SYSTEM	-0.244	2.011	Mediation effect
ES> RA>ADOPTION OF LBM SYSTEM	0.422	4.967	Mediation effect
FC> PEOU>ADOPTION OF LBM SYSTEM	0.173	-2.85	No mediation effect
FC> RA>ADOPTION OF LBM SYSTEM	-0.205	-6.108	No mediation effect

5.8 Upper Limit and Lower Limit

To verify and confirm the mediating effect, the upper limits (UL) and lower limits (LL) were further established using the bootstrapping procedure. Data for the indirect effect of the independent variable and dependent variables were taken from bootstrapping using PLS-SEM software. The details of the Excel calculation are summarized in Table 5.11 where the rule of the upper and lower limit confirms the mediating effect. For the mediating effect of RA on organizational readiness and LBM system adoption, the value of UL was 0.453 and LL is 0.157, which is the positive value for the both of LL and UL limit.

For the mediating effect of PEOU on the external support and LBM system adoption, the value of UL was 0.137 and LL was 0.002, both of which were positive. For the mediating effect of RA on external support and LBM system adoption, the value of UL was 0.333 and LL 0.145, both of which were positive. The results answered research question 5, 6, and 7.

Table 5.12
The Result of Upper Limit and Lower Limit for Mediating Effect

Constructs	**Path a**	**Path b**	**Indirect Effect**	**SE**	**t value**	**95% LL**	**95% UL**
OR>PEOU>adoption of LBM system	0.954	-0.284	-0.271	0.132	-2.058	-0.529	-0.013
OR>RA>adoption of LBM system	0.540	0.566	0.305	0.075	4.0488***	0.157	0.453
ES>PEOU>adoption of LBM system	-0.244	-0.284	0.069	0.034	2.012**	0.002	0.137
ES>RA>adoption of LBM system	0.423	0.566	0.239	0.048	4.967***	0.145	0.333
FC>PEOU>adoption of LBM system	0.173	-0.284	-0.049	0.017	-2.859	-0.083	-0.015
FC>RA>adoption of LBM system	-0.206	0.566	-0.116	0.019	-6.109	-0.154	-0.079

UL= upper limit with 95% confident interval
LL= lower limit with 95% confident interval
*P < 0.01****

5.9 The Effect size

The effect size (f^2) is to evaluate R^2. R^2 is measured by comparing the ratio of variance explained by omission of selected exogenous variable from the model. The change is calculated by estimating the model in two stages (with and without the mediating variable). The result of f^2 is shown in Table 5.13. The following formula was used to calculate f^2. According to Cohen (1998), the result indicates that the effect size f^2 of PEOU and RA was small.

$$f^2 = R^2 \text{ included} - R^2 \text{ excluded} / 1 - R^2 \text{ included}$$

Table 5.13
Effect Size

Constructs	**R^2 included (with mediator)**	**R^2 excluded (without mediator)**	**f^2**
PEOU	0.23	0.19	0.05
RA	0.23	0.17	0.08

5.10 Predictive Relevance of Model (Q^2)

Predictive relevance (Q^2) was examined by using the blindfolding technique. The blindfolding predicts the data points of the variables in a reflective measurement model of endogenous constructs and items (Hair et al., 2014). Q^2 represent show the model recreates the observed values and the parameter estimates. Q^2 greater than zero means the model has predictive relevance and Q^2 less than zero indicates that the model has less predictive relevance (Fornell and Cha, 1994).

The differences in both Q^2 can be obtained using the techniques of cross-validated redundancy or cross-validated communality. Cross-validated redundancy measures the capability of the path model to predict the endogenous variable indirectly from the prediction of the latent variable. Cross-validated communality is an estimate of the endogenous target construct in predicting the omitted data point.

By using blindfolding, the result of Q^2 cross-validated redundancy for adoption was 0.122 (medium) and Q^2 cross-validated communality was 0.493 (large). Predictive relevance is categorized into three values of 0.02 = small, 0.15 = medium and 0.35 large (Hair et al., 2014). The result of the path model indicated that the values of Q^2 were medium and large. According to Hair et al. (2014), cross-validated redundancy is the best approach to explaining the predictive relevance of a model, where in this study the value was 0.122 (medium).

5.11 Summary of Hypotheses Testing

The following summarizes the findings on the testing of the research hypotheses.

H1: Organizational perceptions have a significant effect on the adoption of the load-bearing masonry (LBM) building system.

The result confirmed the direction of hypothesis H1 as predicted. Organizational perceptions of perceived ease of use and relative advantage had a significant effect on the adoption of LBM building system. The result indicated that perceived ease of use had a significant effect on adoption (t value = 1.922, $p < 0.1$) and relative advantage had a significant effect on adoption (t value = 6.180, $p < 0.01$). Therefore, H1 was supported.

H2: Organizational readiness has a significant effect on organization perceptions.

The result corroborated the direction of hypothesis H2 as predicted. Organizational readiness was found to have a significant effect on organizational perceptions. Specifically, organizational readiness had a significant effect on perceived ease of use (t value = 18.160, $p < 0.010$) and relative advantages (t value = 10.232, $p < 0.01$). Therefore, H2 was supported.

H3: External support has a significant effect on organization perceptions.

The result confirmed the direction of hypothesis H3 as predicted. External support was shown to have a significant effect on organizational perceptions. Specifically, external support had a significant effect on perceived ease of use (t value =3.937, $p < 0.01$) and relative advantages (t value = 7.290, $p < 0.01$). Therefore, H3 was supported.

H4: Facilitating conditions have a significant effect on the organisation perceptions**.**

As predicted, the direction of hypothesis H4 was confirmed. Facilitating conditions had a significant effect on organizational perceptions. In particular, facilitating conditions were found to have a significant effect on perceived ease of use (t value = 2.675, $p < 0.01$) and relative advantage (t value = 3.611, $p < 0.01$). Thus, H4 was supported.

H5: Organization perceptions mediate the relationship between organizational readiness and adoption of LBM building system.

The result indicated that perceived ease of use did not mediate the relationship between organizational readiness and adoption (t value = -2.057, $p > 0.05$). However, relative advantage was found to mediate the relationship between organization readiness and adoption (t value = 4.048, $p < 0.01$). H5 was supported.

H6: Organizational perceptions mediate the relationship between external support and adoption of load-bearing masonry (LBM) system.

The result showed that perceived ease of use mediated the relationship between external support and adoption (t value = 2.011, $p < 0.05$). The result also found relative advantage to mediate the relationship between external support and adoption (t value = 4.967, $p < 0.01$). Therefore, H6 was supported.

H7: Organization perceptions mediate the relationship between facilitating conditions and adoption of LBM building system.

The result showed no support for H7. Perceived ease of use did not mediate the relationship between facilitating conditions and adoption (t value = - 2.859, $p > 0.05$). The result also demonstrated no mediation of relative advantage in the relationship between facilitating conditions and adoption of LBM building system (t value = - 6.108, $p > 0.05$).

5.12 Summary

Regarding to the aim of this study to a proposed framework of the factors influencing the adoption of the LBM building system, the PLS-SEM was applied to test the proposed hypotheses. Analysis started with the results of a pilot study. All the constructs were considered reliable and acceptable for the further analysis. After actual data were collected and analyzed, the results showed the measurement and structural model.

Measurement model was determined the validity and reliability of the construct, meanwhile the structural model was determined the relationship of the latent variables. Finally, the summary of the hypotheses results were presented. The results indicated the hypotheses no. 12,3,4,5,6 were significant meanwhile hypothesis no.7 was not significant. In the next chapter will present a comprehensive discussion of the results.

CHAPTER SIX

DISCUSSION OF FINDINGS

6.1 Introduction

This chapter discusses the results presented in the previous chapter in greater detail by linking them to theory and past studies. It then highlights the knowledge contribution, implications of the findings for theory, methodology and practice.

6.2 Outline of the Study

This study empirically tested a framework developed to explain the relationship between the factors purported to influence the adoption of the LBM system in the Malaysian housing industry. The factors examined were organization readiness, external support, and facilitating conditions. These factors were hypothesized to influence organizational perceptions (i.e., perceived ease of use and relative advantage), which subsequently proposed to affect the adoption of the LBM system. To meet the research questions, this study was conducted among housing developer firms in Peninsular Malaysia and the following the research questions answered:

Q1. Do perceptions of the organization influence the adoption of LBM building system among housing developers in Malaysia?

Q2. Does organizational readiness influence organizational perceptions among housing developers in Malaysia?

Q3. Does external support influence organization perceptions?

Q4. Do the facilitating conditions influence organizational perceptions?

Q5. Do organizational perceptions mediate the relationship between organizational readiness and LBM building system adoption?

Q6. Do organizational perceptions mediate the relationship between external support and LBM building system adoption?

Q7. Do organizational perceptions mediate the relationship between facilitating conditions and LBM building system adoption?

6.3 Discussion of the Results

The result of this study showed that organizational perceptions (i.e., perceived ease of use and relative advantage) influenced developers' decision to adopt the LBM building system in their project. This result supports the previous finding by Agarwal and Prasad (1998). Perceived relative advantage was found to have a higher significant effect than perceived ease of use on the organization. This result is consistent with past findings (Al-qirim, 2007; Henderson et al., 2012; Ramayah et al., 2013), which found that relative advantage was a strong predictor of technology adoption. The finding suggests that the LBM building system tends to be adopted because it offers benefits such as efficiency and performance to the potential adopter in reducing the completion of the construction works. Adedeji (2012) indicated that the masonry system tends to be more efficient than the traditional construction method. Subsequently, the adoption of the LBM building system would bring business growth and allowing the developer firms to be competitive in the housing industry. Yusof et al. (2011) pointed out that the adoption of the technology innovation is crucial if firms wish to survive in a highly competitive business. Additionally, according to Abdul Aziz (1994), the adoption of the technology is an important to drive the construction firms into international as well as contribute for long-term profitability.

The next important factor is organization's perception about the ease of use. This confirms the importance of the role of perceived ease of use in the decision of adoption (Ooi & Tan, 2016; Venkatesh & Morris, 2000). Davis (1989), Nan et al., (2008) and Lowry (2003) in their studies demonstrated the easily of the system/ technology would increase the level of adoption. For this study, the respondents believe the LBM building system technique is easier method and influence the level of the adoption in their future projects. The result similar with study by Majid et al., (2008) in construction technology such as IBS.

The present study also found that organizational readiness had a significant effect on organizational perceptions. The more resources the developer firms have regarding knowledge of staff, finance, and technology, the more favourable their perceptions are about the ease of use and relative advantage of the LBM building system. The result is in tandem with the finding by El-gohary (2012) and showed organization readiness has a significant influence on the perceived ease of use and relative advantage. In addition, the result indicated if firms have high organization readiness, the more likely to have a higher perception of the ease of use and relative advantage of the technology. This suggests that organization's readiness fosters the organization perception regarding the LBM system. Organizations with adequate resources are expected to practice using the system and believe the system is easy to use and increase the performance of work. Thus, it becomes purpose to introduce the LBM system in their firm. The result implies that when the organization is ready, it is likely to have confidence in using the LBM building system.

In comparison to other factors of external support and facilitating conditions, the present study revealed that organizational readiness was the strongest predictor of organizational perceptions. This result indicates that housing developer firms are driven to adopt the LBM system in their housing projects because of the adequate resources of their firms rather than other factors. This is consistent with studies by (Tsai & Tang, 2012), which indicate that the organization readiness is an important factor for the organization in the adoption of the technology.

External support was also found to have a significant effect on perceived ease of use and relative advantage. It showed that external supports are also an important contributing effect on perceptions and decision to adopt the LBM system in the developer firm. The results consistent with past findings (Al-qirim, 2007; Premkumar & Roberts, 1999; Scupola, 2009), which indicated that the availability of external support was an important determinant of technology adoption in organizations. Strong external support such as from the government and contractor can encourage developer firms to form a positive opinion of the LBM building system. The training programs provided by the government, the knowledge of the contractor and proper supervision of the contractor are likely to foster a favourable perception of the LBM building system adoption in the organization. However, supplier support was found to be a non-significant component of external support. The results effected by the respondents, where the developers have in-house project teams in their firms. Therefore, they do not appointed external resources such as suppliers to complete their housing project. The insignificant result of the supplier support is similar to a study by A-Qirim (2007).

Facilitating conditions were also revealed to have a significant impact on organizational perceptions of perceived ease of use and relative advantage of the LBM building system adoption. The finding is consistent with past studies (Lu et al., 2008; Terzis & Economides, 2011) on wireless network adoption. These results show more environment control such as government policies and regulation standard in the construction industry the more likely it will lead the relationship of organisation perceptions.

From the results, the respondents acknowledged that the facilitating conditions developed of their perception on ease of use and relative advantage of LBM system in the housing construction. In addition, the respondents are willing to get involved in the LBM system in which they need encouragement of policies from the government and regulation standards. In fact, the developers depend on the encouragement through policies by the government in implementing the technology such as LBM system in the housing projects. In additionally, the respondents are concerned about the design pattern of the housing using the LBM system, where the pattern needs to achieve the design regulation standards. Hence, the empirical result for this study shows the effect of facilitating conditions on the organization perceptions and the LBM building system adoption.

Another key finding was the mediation of relative advantage between organizational readiness and adoption of the system. When a developer firm has financial, technological, and human resources, it is likely to perceive that the system has relative advantage to the organization, which increases its propensity to adopt the LBM building system in its projects. This result similar to that of Igbaria et al. (1997) who demonstrated that the relative advantage (usefulness) of the technology mediated the relationship between internal factors and technology adoption.

However, perceived ease of use did not mediate the relationship between organizational perception and LBM building system adoption. It is illustrated by its indirect effect on the LBM system adoption in Table 5.12. The results showed the organisation readiness has a directly positive effect on perceived ease of use but perceive ease of use has a directly negative effect on the LBM system adoption. This result indicates that perceived ease of use is not presented as intervening linking between organization readiness and LBM system adoption. The result corroborates the study by El-gohary (2012).

The result also demonstrated that organizational perceptions of perceived ease of use and relative advantage mediated the relationship between external support and LBM building system adoption. Igbaria et al. (1997) and Davis (1989) also found that perception mediated the influence of external variables on behavioural. The result suggests that external support is an important factor in determining organizational perceptions, which in turn leads to LBM building system adoption. The result also showed that perceived ease of use perception was influenced by government and contractor support, which in turn enhances the likeliness of adopting the LBM building system.

Unexpectedly, organizational perceptions did not mediate the link between facilitating conditions and LBM building system adoption. The results illustrated in Table 5.12 (Chapter five) shows the negative relationships for the indirect effect of facilitating condition and LBM system adoption. From the results, facilitating conditions have a direct positive effect on organization perceptions but there is negative direct effect between organization perception and LBM building system adoption. The result contradicts Terzis and Economides's (2011) finding. In this study, the respondents did not consider facilitating conditions to be necessary for improving their perceptions and hence their subsequent adoption of the LBM building system adoption.

In this study, the developer firms are likely to use the LBM building system because it speeds up the construction work activities. The LBM building system saves construction time, speeds up wall construction, and hence, save cost per square feet per floor (Majid, 1997; Sinha, 2002). The LBM building system is similar to the Lego concept in that works can be assembled easily on site. The LBM building system is constructed by materials such as bricks or blocks units and does not involve large number of other materials. Based on a simple technique and being readily available, productivity is also achieved through simple work done. Also, this system does not involve any expensive machine or costly plan (Thanoon et al., 2004). Finally, the system requires a small workforce and workers can become skilled in their job.

As summary, the research questions and hypothesises of this study were answered, which were: (1) The organization perception influence the LBM building system adoption, (2) organization readiness influence the organization perception, (3) external support influence the organization perception, (4) facilitating conditions influence the organization perception, (5) organization perception (relative advantage) mediated the link between organization readiness and LBM building system adoption, (6) organizational perceptions (perceived ease of use and relative advantage) mediated the link between external support and the LBM building system adoption and (7) no mediation effect between facilitating conditions and LBM building system adoption.

This denoted that organization perception influence the LBM building system adoption. Meanwhile, organization readiness, external support and facilitating condition influence the organization perceptions. In additional, the organization readiness and external supports are designed to influence the organization's perceptions of the technology and then effect on the LBM system adoption.

6.4 Adoption and Implementation of LBM building system

From Table 5.4 (Chapter Five), the adoption of the LBM building system is low which the respondents claimed only 18.6 percent have used the system in their construction projects. Meanwhile, 81.4 percent claimed to have knowledge but have never used the LBM building system in their construction projects. This result is similar with the finding by Abdullah et al. (2009) and the results indicated that the low adoption of the LBM building system is due to lack of knowledge and experience among the industry players particularly in the aspect of design and construction methods. Additionally, the dominance of the RC system within the construction industry has made it difficult for this system to be implemented into construction projects.

The implementation and usage of the LBM building system by the housing developer firms are illustrated in Table 5.5 (Chapter Five). The majority of the usage of the LBM building system is in housing projects with 14.4 percent. Meanwhile, 3.4 percentage is used for the retaining walls. Only 1.0 percentage combined the LBM building system with RC frame system such as for the frame structure such as columns and beams. Although the adoption of this system is still low, some of the housing developer firms have acknowledged this system in their construction projects.

6.5 Implications of Study

The findings of the present study have several implications for theory and practice. The following elaborates the implications.

6.5.1 Knowledge Contributions

This study contributes to a theoretical understanding of the factors that influence the adoption of LBM building system at decision stage of adoption among developer firms in Malaysia. This empirical study applied the TAM and IDT models in explaining the adoption of the LBM building system. Accordingly, the total variance explained (R2) in adoption by TAM and IDT was 23 percent. The first contribution to the body of knowledge is the validity of TAM and IDT in predicting organization level technology adoption such as LBM building system. The results showed that perceived ease of use from TAM and relative advantage from IDT had a significant effect on the LBM building system adoption. The findings are consistent with other studies stem (Giovanis et al., 2012; Kou & Lee, 2011; Tung et al., 2008). Therefore, TAM and IDT are useful in explaining the LBM building system adoption among housing developers firm.

Secondly, the present study contributed to offering empirical evidence on the significant effect of organizational readiness, external support, and facilitating condition on perceived ease of use and relative advantage. The extraneous factors significantly influenced organizational perceptions with a total variance explained (R^2) in perceived ease of use of 76.2 percent and relative advantage of 71.8 percent.

Thirdly, this study also investigated the mediating impact of organizational perceptions between organizational readiness, external support, and facilitating conditions on LBM building system adoption. The results showed that organizational perception of relative advantage mediated the relationship between organizational readiness and LBM building system adoption and between external support and LBM building system adoption. However, organizational perceptions did not mediate between facilitating conditions and LBM building system adoption. Consequently, this study demonstrated the varying results of the mediation effects on the LBM building system adoption.

Fourthly, the research findings provide an extended model of TAM and IDT by including other factors, namely, organizational readiness, external support, and facilitating conditions, which were not considered earlier. The present study is different from the work of Abdullah et al. (2009) who focused on the adoption of the LBM building system among industry players without considering any theoretical links between the factors and adoption.

Finally, this study provides a framework for LBM building system adoption (Figure 3.7 in chapter three), which was developed by integrating TAM and IDT theory.

6.5.2 Practical Implications

The findings have important implications for policymakers as well as housing developers.

6.5.2.1 Policies Makers

Government agencies and institutions related to construction will have a better understanding of the factors influencing the adoption of the LBM building system by developer firms based on the findings reported here. Consequently, they can use the information to plan future construction policies and strategies for housing developer firms.

Firstly, the government agencies can also develop policies to encourage developer firms to have the necessary resources such as finance and technology for the future adoption of LBM building system. The government agencies with the assistance of the Construction Industry Development Board (CIDB) can provide suitable training to improve the knowledge about the LBM building system among developer firms, contractors, and consultants. These industry players require specific training to implement the LBM building system for construction activities successfully.

Also, related agencies such as REDHA could encourage developer firms to use the LBM building system in their projects by promoting the product (housing made from LBM system method) to potentials buyer. When the public is aware and understands the benefits of the LBM building system, there is a possibility for demands for the product increase, leading towards more usage of this system among the developing firms.

6.5.2.2 Housing Developers

The findings suggest that developer firms will adopt the LBM building system in their projects because the system is easy to use and has relative advantages. Ease of use and relative advantage are driven by factors namely the readiness of the organization, external support, and facilitating conditions. The findings highlight the need for developer firms to enhance their resources when adopting the LBM building system. As external support had a significant effect on organizational perceptions, developer firms need to employ knowledgeable contractors in their housing projects.

From the results, relative advantage was more important than ease of use in the adoption of the LBM building system. That is, the adoption of the LBM system is likely to happen when developer firms know about the benefits of using the system in that it is more efficient to use than the traditional methods and increases the performance of the projects. In this regard, developer firms are encouraged to have an effective collaboration with relevant partners in the industry such as architects, consultants, and government bodies to improve the knowledge and technical skills among their employees. Having the relevant knowledge and skills and other resources is important as they could make the developer firms ready to use the system. This recommendation is consistent with the result that relative advantage intervened between organizational readiness and LBM building system adoption. Relative advantage was also found to intervene between external support and the LBM building system adoption.

6.5.3 Methodological Implications

The use of PLS to test hypotheses in the context of the construction technology study is still relatively underutilized since the very limited study has employed PLS as their data analysis technique (Memon et al., 2013). This study provides validity and reliability of the of the organization perceptions on the LBM building system adoption as well as factors effect on the organization perceptions. Although, the information technology studies have established its empirical results, the construction technology research has been unevenly tested for application of the model. Thus, this study has shown the empirical results through the PLS analysis in the context of construction technology especially LBM building system.

Secondly, this study also contributes to the understanding of the utilization of multiple mediators testing by using SEM-PLS analysis technique. It adds to the methodological contribution on multiple mediation analysis by providing a deeper understanding of the effect organization perceptions such as perceived ease of use and relative advantage on the adoption of LBM building system. By using the multiple mediation analysis, a comprehensive approach can be established to all the relationships and links between the numerous variables in any framework.

6.6 Summary

This chapter discussed in detail of the result findings. It highlighted the answers of the research questions and hypothesized of the study. From the data analyzed, the findings achieved six from the seven of the research objectives. The findings indicated that research objectives no.1,2,3,4,5,6 were achieved, however research objective no.7 was not. These answers that organization perception influences the LBM building system adoption meanwhile, organization readiness, external support and facilitating condition influence the organization perceptions. Organization readiness and external supports are designed to influence the organization's perceptions of the technology and then effect on the LBM system adoption. It then, highlighted the knowledge contributions, an implication for the theoretical, methodological and as well as practical implication. The next chapter will presents conclusions and recommendations of the study.

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This chapter highlights the conclusions of the study. As a conclusion of this study a framework was developed to explain the relationship between the factors purported to influence the adoption of the LBM system in the Malaysian housing industry. Then, presents some recommendations for future study as well as for construction industry.

7.2 Conclusions

This study addresses the seven research objectives on the adoption of LBM building system. To answer the aims of the study, a framework was developed to explore various factors of LBM building system adoption at decision phase by surveying housing developer firms in Malaysia. In particular, it sought to understand the influence of organization perceptions on the LBM building system adoptions and to what extent the factors could influence organizational perceptions of ease of use and relative advantage as the driving forces decision to adopt the system. Additional, to understand the mediation link of organization perceptions between organization readiness, external support, facilitating conditions and LBM building system adoption.

This study revealed that factors of organization's perception, namely as perceived ease of use and relative advantage influence on the LBM adoption. The finding suggests that the LBM building system tends to adopt because it offers benefits to the firms and easily of the LBM building system technique would increase the level of adoption.

Additionally, the findings showed the organizational readiness influence the organization perceptions. The findings indicated if the firms have high organization readiness, the more likely to have perception of ease of use and relative advantage of the technology such as LBM building system. This study suggests the organization readiness fosters the organization perceptions regarding the LBM building system adoption.

External support was found to influence the organization's perception. The findings showed the availability of the external support important to influence the perceptions of the LBM building system adoption. Furthermore, facilitating conditions also influence the organization perceptions. The findings showed, the more encouragement policies from the government the more likely it influences the organization perceptions on the LBM building system adoption.

Another finding was organization perceptions mediated the link between organizational readiness and adoption of the system. When a developer firm has financial, technological, and human resources, it is likely to perceive that the system has relative advantage to the organization, which increases its propensity to adopt the LBM building system in its projects.

The result also demonstrated that organizational perceptions mediated the relationship between external support and LBM building system adoption. External support is an important factor in determining organizational perceptions which in turn lead to LBM building system adoption.

However, organizational perceptions did not mediate the link between facilitating conditions and LBM building system adoption. The respondents did not consider facilitating conditions to be necessary for improving their perceptions and hence their subsequent adoption of the LBM building system adoption.

This study achieved six research objectives in reveal the factors influencing on the LBM system adoption. Findings also provided a framework for LBM building system adoption in Malaysia, which was developed by integrating TAM and IDT theory.

Finally, studies on the LBM building system adoption is expected to invite significant attention from the construction industry players as well as the academic industry. This study offers a glimpse of how the industry players, the government and the academic, industry could learn from the finding presented here, especially in actively promoting the use of the LBM building system in future development projects for sustainability purposes. Since the government is committed to providing affordable houses to the public, the use of the LBM building system is a step towards the right direction as it benefits not only the developer firms but also the government and the public. As the prices of the construction materials keep increasing, LBM building system provides a cheaper alternative in a good quality particularly for housing. The potential cost saved by using the LBM building system is expected to be able to reduce the market prices for houses, which contribute to the government's aim of providing a sufficient supply of affordable houses especially for medium and low-income community groups in Malaysia.

Recommendations for Future Study

The limitations of this research give rise to opportunities for future researchers to address. The first limitation relates to the generalizability of the findings. Since this study focused on developer firms only, future studies could enlarge the scope to include other industry players such as contractors, consultants, architects, and suppliers.

The result indicated that relative advantage, perceived ease of use, organizational readiness, external support, and facilitating conditions explained 23 percent variance in the LBM building system adoption. The result implies that other factors could influence adoption in future research. For example, knowledge of construction stakeholders, quality of the product, organizational culture, and customer demands are suggested factors for future studies. Additionally, other innovation attributes from IDT theory such as compatibility, observability, and trialability could be considered.

Since this research focused on the decision to adopt of the LBM building system, future studies could look into the effect of such actual adoption and organizational performance of construction firms. Even though the adoption of the LBM building system is claimed to contribute to housing projects cost saving and enhance the profits of companies, empirical evidence is needed to bolster such claim and to convince developer firms to use the system in their housing projects. That is, future research should consider actual adoption and organizational performance as a part of the research model. However, since the effect of the use of the technology cannot be realized immediately, future studies may wish to employ a longitudinal approach. To get an in-depth understanding of the adoption process, qualitative methods should be considered. The use of observation or open-ended interviews can reveal the dynamics and mechanisms of the decision-making process of developer firms in using or not using the technology.

Recommendations for Construction and Housing Industry

Based on the results in this study, it has become imperative to put up some recommendations for construction and housing industry in the future and these include:

Accelerated LBM building system is advocated for housing projects as an alternative method cheaper than the RC system. It is faster in operation and it reduces number of the labour required for the construction works. LBM building system could produce the products (houses) faster than RC system.

Promote to use of LBM building system as cost effective with appropriate standardised component and design's specification.

Establishment of the factories/ manufacturers that produce standard components of the bricks/blocks. Consequently, the quality of materials could be controlled and maintained.

Specialization on the building materials at entrepreneurship scale should be facilitated to improve interest among the builders. With a small scale production workshop set up on site, it easy for replication of building component. It is can reduce the problem of the transportation, delay of materials and increase the operation of construction activities.

APPENDIX 1

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A Framework to Facilitate the adoption of load-bearing masonry (LBM) technology in the Malaysian housing industry

Dear respected respondent,

This questionnaire is designed to study the influence of organization perceptions on the adoption of load-bearing masonry (LBM) technology: a study on Malaysia housing developer firms. We pledge you to spend your little time (approximately 10 minutes) to answer this questionnaire. The study is purely academic and the answer you provide will be used only for our research and will help in gaining a better understanding of the factors influencing a decision to adopt of load-bearing masonry system in the Malaysian construction industry. All the information provided here will not be disclosed for any other reasons.

Your participation in this research is very much appreciated and thanks for your time.

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Definition of Load Bearing Masonry (LBM) technology

Load Bearing Masonry (LBM) technology is a method where the elements of a structure are built using masonry units (e.g: bricks/blocks or interlocking brick or block system). Load bearing masonry wall is a concept where the floors and walls work together as a system, each giving support to others. From frame structure, the beams, columns can be built from masonry as well as stairs and

APPENDIX I1

SECTION I: DEMOGRAPHIC

Please (/) in the appropriate boxes.

1. Please indicate the type of your firm:

☐ Private firm
☐ Public firm
☐ Others (please specify)________________

2. How many employees work for your firm?

☐ Less than 30 employees
☐ 31 to 75 employees
☐ 76 to 120 employees
☐ More than 120 employees

3. How long has the company been in the construction industry?

☐ Less than 10 years
☐ 11to 20 years
☐ More than 20 years

4. Your job position:

☐ Managerial level
☐ Professional (Architect, Engineer)
☐ Senior Executive level
☐ Others (please specify)_______________

5. Numbers of years in your current job position:

☐ Less than 10 years
☐ 10 to 15 years
☐ 15 to 20 years
☐ More than 20 years

6. Please indicate your firm's categories:

☐ Use LBM system in the projects
☐ Non-user with knowledge of LBM system

7. If used, please specify the implementation of the LBM system in your projects:

☐ Housing projects
☐ Commercial projects
☐ Wall/retaining wall projects
☐ Frame structure (eg: columns, beams or staircases)
☐ Others (please specify)______________

8. Company's name and location:

____

SECTION II: FACTORS INFLUENCE ADOPTION OF LOAD BEARING MASONRY (LBM) BUILDING SYSTEM

Please indicate your respond categories. For each statement, please tick (/) in the appropriate number to indicate whatever it is.

Strongly disagree	Disagree	Moderate	Agree	Strongly Agree
1	2	3	4	5

No	Organization perceptions	Score				
OP1	LBM building system method is easy to understand	1	2	3	4	5
OP2	It is easy for the company to get information about LBM building system	1	2	3	4	5
OP3	It is easy for the workers to become skillful at using LBM building system	1	2	3	4	5
OP4	Easy for the workers in gettin information about LBM building system method	1	2	3	4	5
OP5	the storage of the material (bricks or blocks) becomes manageable when implement the LBM building system at construction site	1	2	3	4	5
OP6	LBM system would enhance project efficiency	1	2	3	4	5
OP7	Using LBM building system for the housing project is the way to move forward and more competitive in the construction industry	1	2	3	4	5
OP8	Using LBM building system would improve housing project performance	1	2	3	4	5
OP9	Using LBM building system in the project enables the company to accomplish construction works more quickly	1	2	3	4	5

OP10	Using the LBM building system would make it easier to complete the housing projects	1	2	3	4	5
OP11	LBM building system is useful for the housing construction projects	1	2	3	4	5

9. This question to measure the firm perceptions about the LBM system. The perceptions of your firm for the LBM building system based on the following statement;

Highly not important	Not Important	Moderate	Important	Strongly Important
1	2	3	4	5

10. This question is to measure the facilitating conditions. Facilitating conditions are the external control related to the policies and regulation standard. Please rate the importance of the following issues in term of your firm's decision whether or not to adopt LBM system.

No	Statement of facilitating conditions	Score				
FC1	Company policies encourage the implementation of LBM building system for our housing projects	1	2	3	4	5
FC2	LBM building system required for design regulation standard	1	2	3	4	5
FC3	Government needs to be set up laws and regulations for supportive LBM building system implementation	1	2	3	4	5
FC4	Government policies encourage the usage of LBM building system in housing development projects	1	2	3	4	5

No	Statement of external support	Score				
GV1	Incentive from the government to the firm that used LBM building system	1	2	3	4	5
GV2	The government market the products (houses) using LBM building system	1	2	3	4	5
GV3	Government promotes the use of the LBM system for housing projects	1	2	3	4	5
GV4	The government needs to hire the agencies that provide provide LBM system training	1	2	3	4	5
GV5	The government promotes this LBM building system by offering free training session	1	2	3	4	5
CON1	Contractor experiences in LBM building system work	1	2	3	4	5
CON2	Contractor has enough control for site management when using LBM building system	1	2	3	4	5
CON3	Contractor needs to have proper supervision of LBM building system	1	2	3	4	5
CON4	Proper involvement of subcontractor for LBM building system	1	2	3	4	5
CON5	Enough cash flow from contractor	1	2	3	4	5
CON6	Contractor needs to have the effectiveness of cost control system	1	2	3	4	5
CON7	A contractor needs to have right information flow	1	2	3	4	5
SUPP1	Good turnover rate from the supplier	1	2	3	4	5
SUPP2	Supplier needs to have top management support	1	2	3	4	5

SUPP3	Capability of supplier's key personel	1	2	3	4	5
SUPP4	Good of services for supply and delivery the materials from the supplier	1	2	3	4	5
SUPP5	Competency of supplier's proposed team	1	2	3	4	5

11. The question is to measure the external support. External support is the availability of the external parties to support the implementation and adoption of LBM system. Please rate the importance of following statement.

12. The question to measure the factor organizational readiness. Organization readiness is the availability of the firm resources such as technology, financial and staff for adoption of the LBM system. Please rate the importance of following statement.

No	Statement of organizational readiness	Score				
OR2	A firm requires sufficient financial resources for employees' training	1	2	3	4	5
OR3	A firm requires a software in designing the LBM system	1	2	3	4	5
OR4	A firm requires enough financial resources for modules or technical documents	1	2	3	4	5
OR5	A firm requires management support in the implementation of LBM system	1	2	3	4	5
OR6	A firm requires an innovative staff in the practicing of LBM system	1	2	3	4	5

OR7	A firm requires documented modules or technical documents to gaining mastery in the LBM system	1	2	3	4	5

SECTION III: ADOPTION OF LOAD BEARING MASONRY (LBM) BUILDING SYSTEM

Strongly disagree	Disagree	Moderate	Agree	Strongly Agree
1	2	3	4	5

13. The question is to measure an adoption of the LBM building system. Your firm is intent to adopt the LBM system in the future based on following criteria:

No	Statement for LBM system adoption	Score				
SA1	LBM building system offers fewer workers at a construction site	1	2	3	4	5
SA2	Reduce wastage at a construction site	1	2	3	4	5
SA3	Minimize the materials at a construction site	1	2	3	4	5
SA4	Improve the cleaner environment at a construction site	1	2	3	4	5
SA5	Improve the quality of work at construction works	1	2	3	4	5
SA6	Improve safe environment at a construction site	1	2	3	4	5
SA7	Reduce maintenance works at a construction site	1	2	3	4	5
SA8	Minimizes the total cost of housing projects	1	2	3	4	5

Comments or suggestions

If you have any comments/ suggestions that you feel particularly important in the context of the LBM system in the construction industry, please use this section for your comments/suggestions.

Thank You,

Your kindly cooperation in this research is very much appreciated.

APPENDIX III

Table: Missing Value

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
peou1	118	100.0%	0	0.0%	118	100.0%
peou2	118	100.0%	0	0.0%	118	100.0%
peou3	118	100.0%	0	0.0%	118	100.0%
peou4	118	100.0%	0	0.0%	118	100.0%
peou5	118	100.0%	0	0.0%	118	100.0%
peou6	118	100.0%	0	0.0%	118	100.0%
ra1	118	100.0%	0	0.0%	118	100.0%
ra2	118	100.0%	0	0.0%	118	100.0%
ra3	118	100.0%	0	0.0%	118	100.0%
ra4	118	100.0%	0	0.0%	118	100.0%
ra5	118	100.0%	0	0.0%	118	100.0%
fc1	118	100.0%	0	0.0%	118	100.0%
fc2	118	100.0%	0	0.0%	118	100.0%
fc3	118	100.0%	0	0.0%	118	100.0%
fc4	118	100.0%	0	0.0%	118	100.0%
gov1	118	100.0%	0	0.0%	118	100.0%
gov2	118	100.0%	0	0.0%	118	100.0%
gov3	118	100.0%	0	0.0%	118	100.0%

gov4	118	100.0%	0	0.0%	118	100.0%
gov5	118	100.0%	0	0.0%	118	100.0%
cont1	118	100.0%	0	0.0%	118	100.0%
cont2	118	100.0%	0	0.0%	118	100.0%
cont3	118	100.0%	0	0.0%	118	100.0%
cont4	118	100.0%	0	0.0%	118	100.0%
cont5	118	100.0%	0	0.0%	118	100.0%
con6	118	100.0%	0	0.0%	118	100.0%
cont7	118	100.0%	0	0.0%	118	100.0%
supplier1	118	100.0%	0	0.0%	118	100.0%
supplier2	118	100.0%	0	0.0%	118	100.0%
supplier3	118	100.0%	0	0.0%	118	100.0%
supplier4	118	100.0%	0	0.0%	118	100.0%
supplier5	118	100.0%	0	0.0%	118	100.0%
or1	118	100.0%	0	0.0%	118	100.0%
or2	118	100.0%	0	0.0%	118	100.0%
or3	118	100.0%	0	0.0%	118	100.0%
or4	118	100.0%	0	0.0%	118	100.0%
or5	118	100.0%	0	0.0%	118	100.0%
or6	118	100.0%	0	0.0%	118	100.0%
decision1	118	100.0%	0	0.0%	118	100.0%
decision2	118	100.0%	0	0.0%	118	100.0%
decision3	118	100.0%	0	0.0%	118	100.0%

decision4	118	100.0%	0	0.0%	118	100.0%
decision5	118	100.0%	0	0.0%	118	100.0%
decision6	118	100.0%	0	0.0%	118	100.0%
decision7	118	100.0%	0	0.0%	118	100.0%
decision8	118	100.0%	0	0.0%	118	100.0%

APPENDIX IV

Table : Normality Test Descriptive Statistics

	N	Min	Max	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
peou1	118	1	5	3.67	1.206	-.764	.223	-.481	.442
peou2	118	1	5	3.53	1.231	-.694	.223	-.587	.442
peou3	118	1	5	3.60	1.156	-.624	.223	-.765	.442
peou4	118	1	5	3.92	.975	-1.574	.223	2.567	.442
peou5	118	2	5	3.90	.919	-.871	.223	.130	.442
peou6	118	1	5	3.96	1.243	-1.086	.223	-.070	.442
ra1	118	1	5	3.50	1.319	-.625	.223	-.906	.442
ra2	118	1	5	3.78	1.170	-.959	.223	-.090	.442
ra3	118	1	5	3.64	1.317	-.684	.223	-.863	.442
ra4	118	1	5	3.71	1.177	-.698	.223	-.778	.442
ra5	118	2	5	4.08	.879	-1.073	.223	.808	.442
fc1	118	1	5	4.13	.902	-1.608	.223	3.141	.442
fc2	118	2	5	4.12	.786	-1.072	.223	1.448	.442
fc3	118	2	5	4.22	.629	-1.043	.223	3.396	.442
fc4	118	2	5	4.30	.631	-.953	.223	2.598	.442

gov1	118	1	5	3.97	1.004	-1.221	.223	1.088	.442
gov2	118	1	5	3.31	1.237	-.437	.223	-1.091	.442
gov3	118	1	5	3.55	1.285	-.926	.223	-.372	.442
gov4	118	1	5	3.97	1.128	-1.293	.223	.890	.442
gov5	118	1	5	3.87	1.271	-1.179	.223	.252	.442
cont1	118	2	5	3.99	.892	-.940	.223	.430	.442
cont2	118	1	5	3.89	1.299	-1.385	.223	.766	.442
cont3	118	1	5	3.92	.962	-1.602	.223	2.791	.442
cont4	118	1	5	3.70	.981	-1.249	.223	1.326	.442
cont5	118	1	5	3.97	.982	-1.214	.223	1.240	.442
con6	118	1	5	4.14	.846	-1.554	.223	3.712	.442
cont7	118	2	5	4.07	.865	-.939	.223	.537	.442
Supplier1	118	1	5	3.90	1.112	-1.160	.223	.531	.442
Supplier2	118	1	5	3.08	1.217	-.252	.223	-1.287	.442
supplier3	118	1	5	3.36	1.412	-.654	.223	-1.021	.442
supplier4	118	1	5	3.83	1.290	-1.088	.223	-.014	.442
supplier5	118	1	5	3.75	1.219	-.869	.223	-.343	.442
or1	118	1	5	3.75	1.191	-.839	.223	-.338	.442
or2	118	1	5	3.64	1.230	-.802	.223	-.426	.442
or3	118	1	5	3.62	1.116	-.660	.223	-.692	.442
or4	118	1	5	3.92	.975	-1.574	.223	2.567	.442
or5	118	2	5	3.93	.949	-.838	.223	-.058	.442
or6	118	1	5	3.95	1.246	-1.061	.223	-.127	.442

decision1	118	1	5	3.58	1.143	-.960	.223	-.155	.442
decision2	118	1	5	3.83	1.088	-.991	.223	.039	.442
decision3	118	1	5	3.86	1.142	-.868	.223	-.336	.442
decision4	118	1	5	3.92	1.098	-1.129	.223	.739	.442
decision5	118	1	5	3.77	1.158	-1.120	.223	.479	.442
decision6	118	1	5	3.76	1.152	-.681	.223	-.653	.442
decision7	118	1	5	3.52	1.363	-.571	.223	-1.057	.442
decision8	118	1	5	3.27	1.394	-.287	.223	-1.353	.442
Valid N (listwise)	118								

APPENDIX V

Table: Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
peou1	.303	118	.000	.835	118	.000
peou2	.300	118	.000	.848	118	.000
peou3	.321	118	.000	.826	118	.000
peou4	.391	118	.000	.707	118	.000
peou5	.341	118	.000	.782	118	.000
peou6	.302	118	.000	.757	118	.000
ra1	.309	118	.000	.833	118	.000
ra2	.337	118	.000	.796	118	.000
ra3	.293	118	.000	.821	118	.000
ra4	.325	118	.000	.799	118	.000
ra5	.321	118	.000	.761	118	.000
fc1	.342	118	.000	.714	118	.000
fc2	.321	118	.000	.754	118	.000
fc3	.340	118	.000	.668	118	.000
fc4	.316	118	.000	.700	118	.000
gov1	.344	118	.000	.768	118	.000
gov2	.315	118	.000	.839	118	.000
gov3	.365	118	.000	.780	118	.000
gov4	.339	118	.000	.752	118	.000
gov5	.336	118	.000	.756	118	.000
cont1	.326	118	.000	.782	118	.000
cont2	.364	118	.000	.706	118	.000
cont3	.388	118	.000	.707	118	.000
cont4	.373	118	.000	.766	118	.000
cont5	.332	118	.000	.781	118	.000
con6	.318	118	.000	.740	118	.000
cont7	.299	118	.000	.792	118	.000
supplier1	.350	118	.000	.766	118	.000

supplier2	.300	118	.000	.838	118	.000
supplier3	.335	118	.000	.803	118	.000
supplier4	.332	118	.000	.768	118	.000
supplier5	.309	118	.000	.815	118	.000
or1	.302	118	.000	.824	118	.000
or2	.309	118	.000	.831	118	.000
or3	.337	118	.000	.812	118	.000
or4	.391	118	.000	.707	118	.000
or5	.317	118	.000	.797	118	.000
or6	.296	118	.000	.763	118	.000
decision1	.390	118	.000	.762	118	.000
decision2	.358	118	.000	.770	118	.000
decision3	.304	118	.000	.804	118	.000
decision4	.293	118	.000	.810	118	.000
decision5	.341	118	.000	.791	118	.000
decision6	.276	118	.000	.837	118	.000
decision7	.291	118	.000	.831	118	.000
decision8	.267	118	.000	.852	118	.000

a. Lilliefors Significance Correction

APPENDIX VI

Ranks

	respond	N	Mean Rank	Sum of Ranks
BIL	early	48	57.04	5362.00
	late	70	67.00	1541.00
	Total	118		

	BIL
Mann-Whitney U	897.000
Wilcoxon W	5362.000
Z	-1.262
Asymp. Sig. (2-tailed)	.207

a. Grouping Variable: respond

Ranks

	level	N	Mean Rank	Sum of Ranks
BIL	Managerial level	30	54.53	1636.00
	non Managerial level	88	60.54	5267.00
	Total	118		

	BIL
Mann-Whitney U	1171.000
Wilcoxon W	1636.000
Z	-.836
Asymp. Sig. (2-tailed)	.403

a. Grouping Variable: level

APPENDIX VII

Table: Total Variance Explained (Harman's single factor test)

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.648	25.322	25.322	11.648	25.322	25.322
2	5.548	12.060	37.382	5.548	12.060	37.382
3	4.177	9.081	46.463	4.177	9.081	46.463
4	3.360	7.305	53.768	3.360	7.305	53.768
5	2.800	6.087	59.854	2.800	6.087	59.854
6	2.619	5.693	65.547	2.619	5.693	65.547
7	1.784	3.878	69.425	1.784	3.878	69.425
8	1.711	3.719	73.144	1.711	3.719	73.144
9	1.326	2.884	76.028	1.326	2.884	76.028
10	1.136	2.471	78.498	1.136	2.471	78.498
11	1.075	2.336	80.834	1.075	2.336	80.834
12	1.014	2.204	83.038	1.014	2.204	83.038
13	.806	1.753	84.791			
14	.785	1.707	86.499			
15	.727	1.580	88.078			
16	.686	1.491	89.569			
17	.533	1.158	90.727			
18	.488	1.061	91.788			
19	.426	.926	92.713			

20	.389	.846	93.560			
21	.333	.723	94.283			
22	.300	.653	94.936			
23	.275	.597	95.533			
24	.272	.591	96.124			
25	.235	.510	96.634			
26	.200	.435	97.069			
27	.194	.422	97.491			
28	.172	.373	97.864			
29	.164	.356	98.220			
30	.131	.284	98.504			
31	.109	.237	98.741			
32	.097	.210	98.951			
33	.091	.198	99.149			
34	.072	.156	99.305			
35	.061	.132	99.437			
36	.054	.116	99.553			
37	.049	.107	99.660			
38	.040	.087	99.746			
39	.033	.072	99.818			
40	.027	.059	99.877			
41	.021	.045	99.923			
42	.014	.030	99.953			

43	.009	.020	99.973			
44	.006	.014	99.987			
45	.005	.010	99.997			
46	.001	.003	100.000			

APPENDIX VIII

List of Published Journal Articles and Conference Papers;

SCOPUS INDEXED

1. Ramli, N.A., Abdullah, C.S., Nawi, M.N.M., (2016), Success Factors and Barriers in the Implementation of Load-Bearing Masonry System: The Case Study of Construction Firms in Malaysia, *International Journal Supply Chain Management,* Vol. 5, No. 3,pp 180-184.

2. Ramli, N.A., Abdullah, C.S., Nawi, M.N.M., (2016), Factors Influence the Adoption of Load-Bearing Masonry System: A Study on Malaysian Housing Developer Firms, *The Social Science Journal*, 11, pp7432-7427

3. Ramli, N.A., Abdullah, C.S., Nawi, M.N.M., (2015), The Study of Load Bearing Masonry (LBM) System in a Developing Country, *Advanced Environmental Biology*, 9(3), pp79-81

4. Ramli, N.A., Abdullah, C.S., Nawi, M.N.M., (2014), Definition and New Directions of IBS Load Bearing Masonry (LBM) System in Construction Industry, *Advances in Environmental Biology*, 8(5),pp 1864-1867.

5. Ramli, N.A., Abdullah, C.S., Nawi, M.N.M., (2014), Key Influences Factors for the Load-Bearing Masonry (LBM) System Adoption in Malaysia Construction Industry, *American Eurasian Journal of Sustainable Agriculture,* 8(7),pp 80-84.

PROCEEDING INDEXED

1. Ramli, N.A., Abdullah, C.S., Nawi, M.N.M., Bahaudin, A.Y.,(2016), Load-Bearing Masonry System Adoption and Performance: A Case Study of Construction Company in a Developing Country, *AIP Conference Proceeding*, 020091-5.

2. Ramli, N.A., Abdullah, C.S., Nawi, M.N.M., (2013), A Study of Potential Load Bearing Masonry (LBM) System in Malaysia Construction Industry, *MATEC Web of Conference*, 15:1-6.

INTERNATIONAL CONFERENCE

1. Ramli, N.A., Abdullah, C.S., Nawi, M.N.M., (2014), Load Bearing Masonry (LBM) System in a Developing Country, *The 4th International Conference on Technology and Operations Management*, Kuala Lumpur 2014.