



UNIVERSITI PUTRA MALAYSIA

***EFFECTIVE INFORMATION MANAGEMENT FOR SMALL AND
MEDIUM-SIZED BUILDING CONTRACTOR COMPANY***

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**EFFECTIVE INFORMATION MANAGEMENT FOR SMALL AND
MEDIUM-SIZED BUILDING CONTRACTOR COMPANY**



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ABSTRACT

The main purpose of this research is to improve the effectiveness of information management in small medium sized building contractor companies. A quantitative questionnaire survey has been conducted to determine the current practice of information management among the contractor companies. Analysis has shown that the cost and equipment information are the best managed information. In contrast, material information is being ranked at last on the effectiveness of management. Therefore, further study has been conducted in order to address the material information management issue. It has been found out that most of the respondents adopted ICT in managing material information, but its effectiveness is not satisfying. The setback that are disappointing the industry players are such as the software is not user-friendly, and it does not give any direct benefit for the users in winning a tender. Hence, a web-based information system is developed by considering all the feedbacks from the industry with the goal of improving the effectiveness of information management. The main function of the system is to record any material transaction made. Secondary functions such as suppliers' transaction history checking, material quality rating, and ordering point notification are also provided in order to improve the material information management of target population. The system proposed had been validated by the industrial players where a number of respondents were approached to try the system by themselves. Lastly, it is recommended to integrate all the information management in one system as this can greatly increase the productivity and efficiency of the company.

ABSTRAK

Tujuan utama kajian ini adalah untuk meningkatkan keberkesanan pengurusan maklumat dalam syarikat-syarikat kontraktor binaan bersaiz sederhana kecil. Tinjauan soal selidik kuantitatif telah dijalankan untuk mengkaji pengurusan maklumat di kalangan syarikat-syarikat kontraktor di Malaysia. Analisis tinjauan tersebut telah menunjukkan bahawa maklumat kos dan peralatan adalah maklumat yang teratur. Sebaliknya, maklumat bahan-bahan binaan adalah maklumat yang paling tidak teratur. Oleh itu, kajian lanjut telah dijalankan untuk menangani isu pengurusan maklumat bahan binaan. Ia telah didapati bahawa kebanyakan responden menggunakan ICT dalam menguruskan maklumat bahan binaan, tetapi keberkesanannya adalah tidak memuaskan. Antara factor-factor yang mengecewakan pemain industri adalah seperti perisian yang tidak mesra pengguna, dan ia tidak mendatangkan apa-apa manfaat yang langsung kepada pengguna ketika bersaing dengan syarikat pelawan untuk mendapatkan perniagaan. Oleh itu, satu sistem maklumat yang berasaskan web telah direka selepas mengambil kira semua komen daripada industri dengan matlamat untuk meningkatkan keberkesanan pengurusan maklumat. Fungsi utama sistem ini adalah untuk merekodkan transaksi bahan binaan. Fungsi sekunder seperti semakan rekod transaksi pembekal, penilaian kualiti bahan, dan peringatan untuk menambah stok juga telah disediakan. Sistem yang direka telah disahkan oleh pemain industri. Responden telah mencuba sistem tersebut dan beberapa komen telah dicadangkan. Akhir sekali, ia adalah digalakkan untuk mengintegrasikan pengurusan semua maklumat dalam satu sistem kerana dengan ini, kecekapan dan productiviti syarikat bina dapatlah ditingkatkan.

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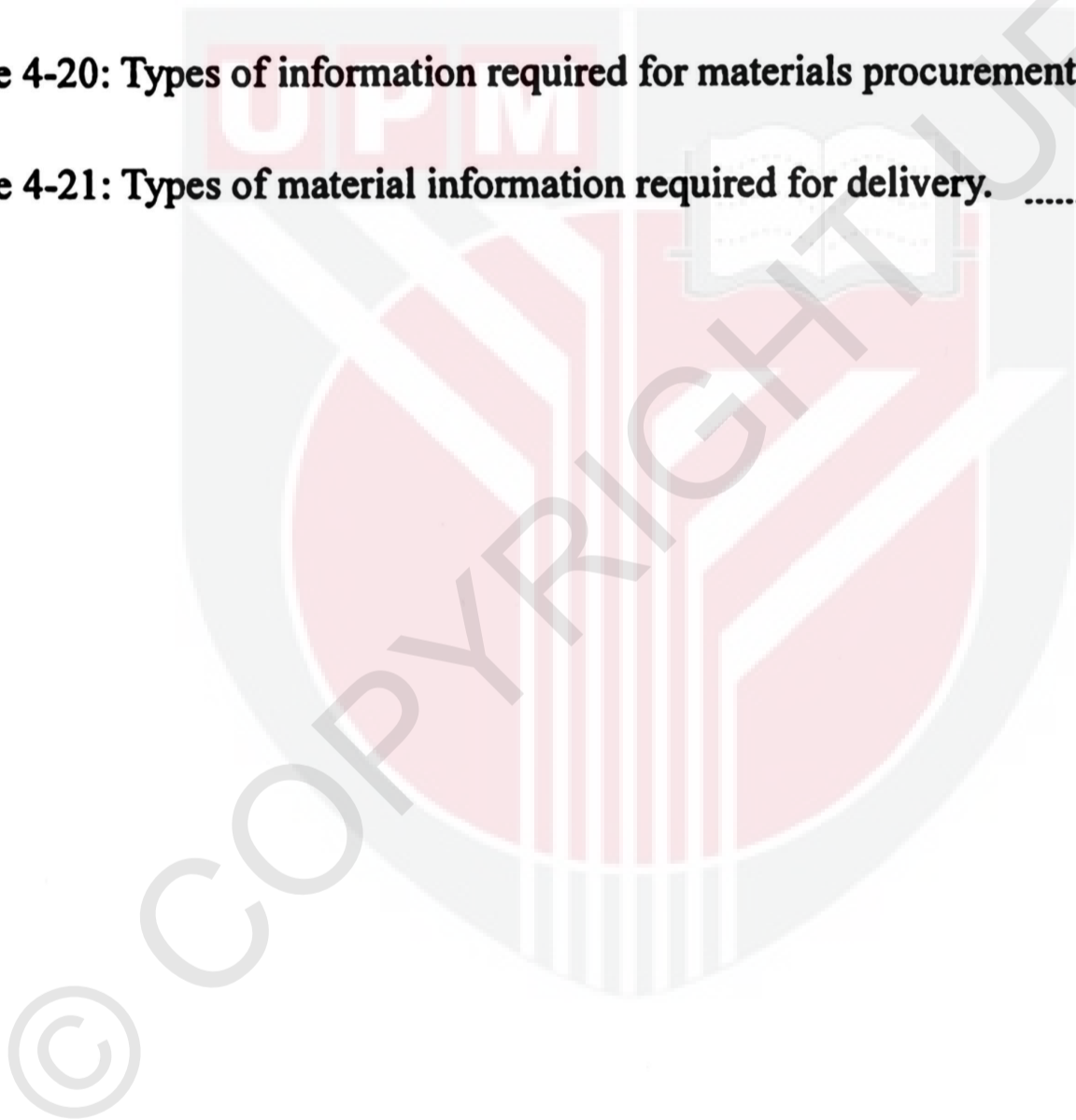
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LIST OF ABBREVIATIONS

BIM **Building Information Technology**

CAD **Computer-Aided Design**

CM **Cost Management**

EM **Equipment Management**

ICT **Information Communication Technology**

IT **Information Technology**

JRK **Jobsite Record Keeping**

MM **Material Management**

RFI **Request for Information**

QCQA **Quality Control / Quality Assurance**

S **Safety**

SMM **Schedule and Means and Methods**

SMT **Submittals**

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

As one of the main economic contributor in Malaysia, the construction industry contributes roughly 3-5% to the Gross Domestic Product (GDP) annually, which in turn provides about 10% employment of the total labor force (CIDB, 2009). However, statistics has indicated that the industry is facing 20% of decline in performance as compared to other industries, despite having strong support from the government. Researches had been done to investigate the causes of the declination, and one of the factors found is due to lack of information sharing in the industry (JBIM, 2007).

Construction projects are highly complex collaborative events that involve various bodies and organizations, e.g. clients, designers, consultants, contractors, and inspectors. Throughout the life of a project, huge amounts of information will be accumulated by all these parties. For example, (Garza & Howitt, 1998) has found out that the information required during construction phase of a building include of request for information, materials management, equipment management, cost management, schedule and means and methods, jobsite record keeping, submittals, safety, quality control and quality assurance, and future trends. However, due the reactive nature of construction contracts and the increased vulnerability of project personnel, these

information is often not transferred nor stored in the way it was intended to be. Xerox (2002) has proven that the information generated within an organization is poorly managed, and in many examples the volume of useful information exiting the organization on a daily basis exceeds that available for immediate use within the organization. From his research, as much as 42% of knowledge goes home at the end of the day instead of being stored or shared within the organization.

The transformation in science and technology has improved the situation where the Information and Technology (IT) has been introduced, enhancing the communication, collaboration and information management processes (Bowden, et al., 2005). Competitive pressures, desire in gaining more profit and client requirements have catalyzed the implementation of new information technology in the industry, especially those pertaining to how project information is exchanged, manipulated and managed (Steward R. A.). Heavy investment has been done by numerous construction firms into information and communication technologies in their quest for improved competitiveness and profitability (Betts, 1999). However, majority of them are yet to taste the proclaimed benefits of IT and are greatly dissatisfied by their IT investment (Pena-Mora, Vadhavkar, Perkins, & Weber, 1999). Reasons such as high maintenance or implementation cost, high cost of specialist software are found to be stopping the industry from adopting IT systems in their projects. Therefore, research with the aim of investigating the effectiveness of information management in construction industry is required and recommendations on improving the issue especially by the method of IT implementation should be provided to increase the productivity and efficiency of the industry.

1.2 Problem Statement

The performance of construction industry is greatly influenced by the effective management of information as huge amount of information flows will occurs during a construction project. It had been identified that the problems related to transmission of information is a very important factor of inefficiency in a construction project (Otjacques, Post, & Feltz, 2003). Also, inappropriate coordination of information had been stated as one of the causes of construction project delays (Sunjka & Jacob, 2013). Besides, an estimation has been made by International Alliance for Interoperability that about 30% of the cost of a construction project is due to the fractured processes and communication of the AEC/Facility Management (FM) industry.

In addition, Memon, Rahman & Aziz (2012) have identified the information and communication related factors as one of the groups of common causes of cost overrun. Slow information flow between parties has been ranked as number 10 out of 35 common causes of cost overrun in construction project through the questionnaire survey conducted by them.

Furthermore, a study conducted towards the construction projects in Tanzania showed that the third major factors of project delays is information delays. Consequences of this delay are determined to be time overrun, cost overrun, negative social impact, idling of resources and disputes (Kikwasi, 2012).

Other than that, the incapability of small medium enterprises contractors in adopting new information technologies such as Building Information Modeling (BIM) might cause them unintentionally “frozen out” from the industry as they are uncompetitive compare to those big players that implement information technology in their projects.

Without the IT, they will have to operate based upon traditional means of

communication such as face-to-face meetings and the exchange of paper documents in the form of technical drawings, specifications and site instructions, which will drastically pull down the performance of a company.

In a nutshell, an improper information management will result in additional construction costs, delays, declination of performance and consequently, bad relationships with the customers. Therefore, the purpose of this research is to investigate the information management issues in small and medium construction companies and improve its effectiveness by proposing a low-cost information technology tool/system.

1.3 Aims and Objectives

The aim of this research is to solve the information management issue in small medium construction company. Therefore, to achieve the aim, the objectives are set as bellows:

- i. To identify the types of information required by contractors in construction project during construction phases in Malaysia.
- ii. To identify the types of information that is not being properly managed in jobsite during construction phase.
- iii. To propose an alternative solution for small, medium construction company (contractors) to manage and organize the selected types of information.

1.4 Scope of Work

Due to the constraint of times and resources, there are certain limitations on this research. The scope of work for this study are as listed below:

- The survey is conducted only to the Grade 5 contractors in Selangor area.
- The study only focuses on the contractors' internal information management during construction phase of a building project.
- The research will only focus on one type of the problematic information (Material Information) obtained through surveys.
- Solution will be proposed to target only one type of the problematic information (Material Information) obtained from surveys.
- The data of the survey is conducted through detailed questionnaire survey.

1.5 Significant of Study

As mention in previous section, improper information management will result in numerous consequences such as additional construction cost, delays, and declination in performance of construction industry. Therefore, the findings of this research will indicate the types of information that are lack of proper management in construction project. Also, the proposed information technology tool/system will help the small and medium-size contractors' company in managing the particular type of information in their projects without investing large amount of resources. This will boost up their performance and efficiency and enable them to be competitive in the industry. Lastly, by having a proper information technology tool, delays and additional cost of construction project can be minimized, and thus the profit of the company will increase.

1.6 Summary

Due to the importance of the construction industry towards the economy of the country, any issues that contributes to the declination in performance of the industry should be handled seriously. As supported by all the statistic and facts, information management problem in construction jobsite is one of the contributing factors to the cost overrun and delay issues in the industry, and therefore, researches should be conducted to come out with potential remedies in addressing the issue. Hence, the research had been proposed with the aim to solve the information management issue particularly in small and medium building contractor companies. The population of study had been set to be the Grade 5 building contractor companies in Selangor area as this is one of the building contractor-concentrated state in Malaysia. The area of study had been scoped into only focusing in detail on the material information management issues due to the constraint of time and resources of the research. Last but not least, this study is significant as it can help to boost up the performance and efficiency of the small medium-sized building contractor company in Malaysia by minimizing the occurrence of cost overrun and project delay problem that are caused by the inefficiency in information management.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

As one of the most information-intensive industry, huge amount of information flows between the project's participants throughout the lifecycle of a construction project. The involvement of those distinct professionals makes the effective management of information exchange crucial. It has been proven that the improper information flow management will often lead to delays, additional costs and consequently bad relationship with the customers (Otjacques, Post, & Feltz, 2003). Therefore, with the transformation of science and technology, new information technologies (IT) has been invented and introduced in the industry to support the fast, efficient development and management of construction projects. However, even though implementation of IT shows obvious improvement on the overall performance of the industry, the industry seems to make slow progress towards implementing IT in their organizations. The reasons behind include the very nature of how the industry operates one-off projects, industry fragmentation, lack of client leadership, low level of technology awareness and training, required up-front investment, on-going maintenance costs and resistance to change. (Steward & Mohamed, 2016)

This chapter aims to review by literature research the types of construction project

information required during construction phase of building project, to study the implementation of IT tools in the industry locally and abroad, the example of IT tools used and the problem of implementation of IT tools in the industry. Also, focus will be put on the selected type of problematic information (Material Information) obtained through questionnaire survey as discussed in Chapter 4.

2.2 Project Information Required at Jobsite

In order to investigate the information management issues at construction industry, the types of information need and requirements have to be figured out. Garza and Howitt (1998) had come out with a list of categories of information needed for a construction project completion. Although the list does not cover 100% of the jobsite information, it includes all the essential information needed to successfully complete a construction project (Ballan & El-Diraby, 2011). The list of information required at construction site is as shown below:

- i. **Request for Information:** All the information exchanged regarding pre-project, correspondence, design, and construction startup. It contains items such as documents pertaining to contract specifications, contract drawings, change orders, shop drawings, and design intent clarifications. This category of information is the most frequently exchanged information in a construction project.
- ii. **Material Management:** All the documents of material required for a construction project, which includes request and procurement of material, determination of the status and location of material inventory, and any special handling or delivery of material.

- iii. **Equipment Management:** This category includes all the documents and information exchanged which related to equipment required on site. For instance, the equipment rentals and allocation.
- iv. **Cost Management:** Refer to all the information and documents related to cost and accounting of a project. For examples, budget pricing, material, equipment cost accounting and purchase orders.
- v. **Site, Schedule and Construction Information:** Refer to all information flow between construction site and office which includes scheduling updates, productivity information, updates drawings, progress reports, visitor logs, and daily site diaries.
- vi. **Quality Control / Quality Assurance Management:** Refer to all quality control and quality assurance documentation. Examples are such as soil reports, inspection results, deficiency lists etc. Main purpose of this documentation is to insure that the work done is qualified according to the clients' requirement.
- vii. **Safety:** This category includes all safety documentation exchanged between site, office and sub-contractors. Some of the reports include accident reports, safety violations and labor force contracts.

2.3 The Role and Importance of Information Technology in the Construction Industry

In 1980s, technological revolution has made Information Technology (IT) an important part of many core business activities (Gaith, Rashid, & Ismail, 2012). It is expected that the implementation of IT in construction industry will soon expand globally. According to (Li, Irani, & Love, 2000), the organizations begin to aware that adoption of IT can maintain their competitive advantage. Bowden et al. (2006) told in their research that information communication technology (ICT) provides new chances to innovative construction companies to upgrade their process of collaboration, communication and information. The conclusion made by Miyatake & Kangari (1993) indicated that IT should be seen as an important resource in today professional practice and that the automatic flow of vital information in a firm is essential. In addition, Luiten & Tolman (1997) also stated in their research that IT can enhance the information exchange among employees of the company or team that handle the design process management and control.

Over the past 30 years, the role of IT in most industry sectors has changed. IT is becoming more and more crucial especially for construction industry where it is used by building practitioners to simulate, analyze and evaluate the anticipated performance of the design, the design of the amenities' delivery process and the design of organizations in carrying out the processes (Gaith, Rashid, & Ismail, 2012). According to Michel et al. (2000), the emphasis of IT application in the industry can be staged into three generation. First generation is the general application on the data processing method of accounting, payroll and analysis of complex numerical calculation, then it evolves to decision support system where functions to manipulate and filter information assisted the decision-making process, and finally, the third generation of

application emphasizes on strategic information system that are critical to company survival in the industry as whole.

Furthermore, it has been shown by Zhang et al. (2009) the use of IT, computer vision system in specifically, can assist in the task of project management to some extent. This statement is made by referring to the application of computer vision in the industry. Computer vision can be used in formulation of 3D objects from 2D images. An image is automatically scanned and work in progress can be measured. In order to evaluate the increase in productivity brought about by IT, Gaith et al. (2012) had conducted a case studies in Jordan, reviewing the perceived benefits of IT adoption in the construction industry. The respondents perceive the benefits of IT adoption as better work quality, increased efficiency, better financial control, better communication, faster and simpler access to public data, greater flexibility to satisfy customers, the possibility of sharing information in general, easier to use a lot of data and the convenience of telecommuting. Therefore, it can be concluded that the implementation of information technology did help to improve the performance, especially in the information management of the industry.

2.3.1 Example of IT Tool Used in Construction Industry – Building Information Modelling (BIM)

With the revolution of science and technology, Information Technology (IT) has been widely used in construction industry. Among the IT tools with feature of information management, Building Information Modeling (BIM) is one of the most trending in the industry recently. According to Azhar et al. (2008), BIM can be defined as the process of development and use of a computer-generated model to simulate the planning, design, construction and operation of a facility. It is a data-rich, object oriented, intelligent and parametric digital representation of the facility, from which users can extract and analyze the data from it to generate information that can be used for the decision making. Other than that, BIM also can be defined as the intelligent plan metric 3D modelling (in particular for the architectural world), and it is also the process undertaken through the lifecycle of a scheme. It provides the industry with a method of collecting and using information across a construction project with the objective of providing a seamless link between the designers, the client, construction professionals, contractor and end user of a project from the project inception through to the final decommissioning of the project after its intended life has expired (Smith, 2012).

2.3.2 Benefits of BIM Implementation

It has been proven by researches and case studies that BIM did brought positive impacts to the construction industry. Even though it has been long time ago since the first introduction of BIM to the construction industry, the BIM processes and activities that contribute to project success, are still evolving. The first generation of BIM emphasized more on efficiency in generating 2D drawings particularly as the design changed. The models at that time is something not essential to the industry. Only after the construction industry began to use models for coordination and clash detection, the industry players started to realize the benefits of BIM. Today, the implementation of BIM is mandated or recommended by the governments worldwide as its value for helping to deliver projects successfully is undoubtable. Some of the major advantages are as discussed below (Brown, 2016).

a) Structural Building Information

BIM implementation improves the structural information management of a building project due to the 3D modelling feature of the software. Information retrieval has becoming much easier and accurate as BIM is a technology that provides users a visual simulation and a digital prototype of a building prior to construction (Weygant, 2011). Compare to the traditional 2D CAD which comprises graphical entities, BIM can provide better visualization with detailed 3D view and thus making the building information extracted from BIM becomes more accurate. This is parallel with a statement made by Taylor and Bernstein, (2008) and Kymmell (2008) that mentioned that the visualization process of BIM could give the project stakeholders a better cognitive of the intended construction as it can provide them a detailed 3D view. For example, compared to traditional method that use 2D drawings, the detail 3D

visualization enables architects and engineers to resolve the “clash detection” disputes more precisely (Harris, Ani, Haron, & Husain, 2014). This statement is further supported by a case study done by (Migilinskas, Popov, Juocevicius, & Ustinovichius, 2013) on the implementation of BIM in the project of Vilnius Municipality complex that shows the utilization of BIM in the project provides a single prepared 3D frame model for visualization, structural analysis, final adjusted 3D model and Facility Management model with related model. Last but not least, BIM is not only beneficial to the industry during the construction phase, it can be useful during the post-construction phase wherein all the information collected throughout the project phases can be utilized to help the clients to maintain their buildings precisely (Harris, Ani, Haron, & Husain, 2014).

b) Time Saving

Other than that, BIM also can be used to manage the site and schedule information as it can be used to simulate and analyze the construction sequences to cut down the construction duration as much as 7% (Azhar, Hein, & Sketo, 2008). The case study done by Migilinskas et al. (2013) on a project in Klaipeda also indicated that the BIM 3D technology had assisted the CM team to reduce time spent for corrections of construction drawing during design stage. Same result had been shown by their case study on the project of MG Valda Victoria office building, where the information in early stage about missed design and potential arising issues provided by BIM was said to help in eliminating delays, and saving time of the project during construction work.

c) Cost and Material Estimation

In addition, BIM also helps in providing material and cost information of a building project. As mention by Azhar et al. (2008), BIM improves the efficiency of cost estimation with up to 80% decrement in time taken, about 3% of cost estimation accuracy and 10% saving of the contract value through clash detection. Furthermore, BIM also assists in managing the information of material and equipment as it can be utilized to manage site planning and logistics which may include machineries' location and temporary access points as quoted by Khanzode et al. (2008). The findings from the case study done by Migilinskas et al. (2013) on the implementation of BIM in the project of Vilnius Municipality complex too shows that the negotiation process with subcontractors and suppliers had been simplified by using the 3D model to estimate the bill of quantities for the work packages. The order and supply of manufactured elements and details for the project too had improved essentially. In addition, his case study on the project of PET plastic raw material plant in Klaipeda had shown that the utilization of BIM can minimized human errors in orders of the materials and products needed at strict time.

2.3.3 Barriers and Issues in Implementing BIM in Malaysia

In order to improve the adoption of BIM in Malaysia construction industry, studies had been conducted to identify the barriers and issues in implementing BIM in Malaysia. In June 2013, a one-day workshop had been held through the collaboration between the Construction Industry Development Board (CIDB), Malaysia and Universiti Teknologi Mara (UiTM) to investigate the obstacles, remedies and advantages of BIM adoption in Malaysia, particularly among the contractors. The table below shows the percentage of issues raised by the participants of the workshop who consist of 51 contractors (Grade 3 – Grade 6), 18 academics from local universities, 8 representatives of government agencies and 13 consultant representatives.

Table 2-1: Barriers of BIM implementation in Malaysia (source: Harris et al., 2014).

Key variables	Issues Raised	Percentage%
Cost	16	26.2
Time	10	16.4
IT (software, hardware, computer)	14	23.0
Readiness	9	14.8
Knowledge	5	8.2
Technology	5	8.2
Information	2	3.3

As shown by the table above, among all the variables raised by the participants, cost factor is the most discussed issue, which occupies 26% of the total variables. The output of the workshop shows that technology financial risk of BIM is the major obstacle as contractors and consultants are burdened to spend on the hardware, software, employment of professionals and to provide staff training in implementing BIM in their organizations. According to contractors, the high initial capital outlay to implement BIM does not assure them to secure any future projects, causing them to lose trust on the Return on Investment (ROI) of BIM implementation. In contrast, this

dilemma might influence the cash flow of a project, especially for minor projects.

Besides, the variable of hardware, software and computer too had been raised during the workshop. CIDB and consultants point out that the compatibility of the BIM software that enables communication and data interoperability between contractors, sub-contractors and other parties is very important as it determines whether the BIM software will improve the productivity and efficiency of the organization or not. Furthermore, the insufficient of competent BIM modelers in Malaysian AEC industry is also found to be one of the barrier of BIM implementation in Malaysia. Also, the contractor's representative did highlight that some local organizations are still resisting to change or are still unready to adopt BIM as a tool in their projects. Both the top management and staffs of the organization play an important role in this issue. The inexpert in-house technical staff to undergo training and not be IT savvy despite the usefulness and economic benefits of BIM.

Table 2-2 summaries the findings of the workshop on the barriers, potential solution and benefits of BIM implementation in Malaysia.

Table 2-2: Obstacles, Potential Remedies and Advantages of BIM Adoption in Malaysia (source: Mohd Harris et al., 2014)

Organisation	No. of Participant	Barriers	Potential Solution	Benefits
Contractors	51	<ul style="list-style-type: none"> The initial upfront expenditure such as purchase of software, conduct BIM training; to appreciate and use of BIM are time consuming prior to being familiar with BIM Not ready with BIM (hardware and software) Staff resistance to change Lack of expertise and knowledge in BIM 	<ul style="list-style-type: none"> Government incentives Enforcement and policy on BIM Accreditation and recognition 	<ul style="list-style-type: none"> Competitive advantage Proposals are better understood through accurate visualisation
Consultants	13	<ul style="list-style-type: none"> The cost of initial investment of BIM is high Stability of the system 	<ul style="list-style-type: none"> Government to provide incentives Sufficient training 	<ul style="list-style-type: none"> Improve design errors Detailed understanding of the design Avoid clashes on drawings
Government Agencies	8	<ul style="list-style-type: none"> Software capability, compatibility and interoperability are questionable 	<ul style="list-style-type: none"> Awareness program Affordable training and software cost Rolling out National policy on BIM Carry out further R&D on user-friendliness of the software and systems CIDB affordable BIM program 	<ul style="list-style-type: none"> Improve project performance Early detection of problem As a database for operation and maintenance phase.
Academician	18	<ul style="list-style-type: none"> Insufficient pool of BIM experts in the industry 	<ul style="list-style-type: none"> To include a BIM course in IPTA teaching syllabi Relevant Government agencies to provide support in terms of trainings and awareness program. 	<ul style="list-style-type: none"> Adopt BIM in construction as a new paradigm shift Lifecycle data can be used in the maintenance and operation of facility
Total	90			

On the other side, a survey that has been conducted by Zakaria et al. (2014) shows that the top five obstacles that slowing down the adoption of BIM in Malaysia are (1) Lack of knowledge about BIM, (2) Clients do not request/enforce BIM, (3) Reluctance from clients, contractors or consultants to implement BIM, (4) BIM is not required by other parties in collaboration and (5) Lack of data of Return on Investment of BIM. The table below is extracted from the work of Zakaria et al. (2014), showing the ranking of their finding on barriers of BIM implementation in Malaysia.

Table 2-3: Rank for Factors of Barriers (source: Zakaria et al., 2014)

	Factors why BIM is not being implemented in Malaysia	RII	Overall Rank
1	Lack of knowledge about BIM	0.950	1
2	Existing CAD system fulfils our need to design and draft	0.804	8
3	BIM is too expensive	0.592	15
4	Lack of training on BIM software	0.608	14
5	BIM does not reduce the time used on drafting compared with the current drawing approach	0.650	12
6	BIM lacks features or flexibility to create a building model/ drawing	0.650	13
7	Clients do not request/enforce BIM	0.950	2
8	BIM is not required by other team members	0.838	4
9	Application of BIM will affect the current process practice	0.779	9
10	Application of BIM will affect the current productivity	0.779	10
11	Legal or contract issue	0.817	6
12	Lack of working procedures and standards	0.675	11
13	Reluctance from Client, Contractors or Consultant to implement BIM	0.875	3
14	Lack of data of Return on Investment of BIM	0.833	5
15	Software related (i.e.: ease of use)	0.808	7

2.4 Material Management in Construction Industry

Material management is the process of planning and managing to make sure that the optimum quality and quantity of materials and installed equipment are properly specified in a timely manner, procured at reasonable cost and are available when needed. The purpose of material management is to improve any activities related to the material flow. It should coordinate purchasing, inventory control, receiving, warehousing, materials handling, planning, and transportation (Dobler & Burt, 1996).

The brief explanation for the material management processes are as shown below (Kasim, 2011).

- **Planning:** Quantifying, ordering and scheduling of material. Planning process is indeed vital to increase productivity, net income, and facilitate the timely completion of construction project.
- **Procurement:** Obtaining of materials and services from other companies to assist the company's operations. It is important to assure the material availability. The typical purchasing procedure is shown in the figure below.
- **Logistics:** Process includes of planning, implementing, and controlling the flow and storage of all goods from raw materials to the product to meet customer requirements.

- Handling: The flow component that provides for the material movement and placement.
- Stock and Waste Control: Stock control can be defined as the technique used to cover and ensure all items are available when required. It is important to have a proper management of stock control for construction materials delivery.

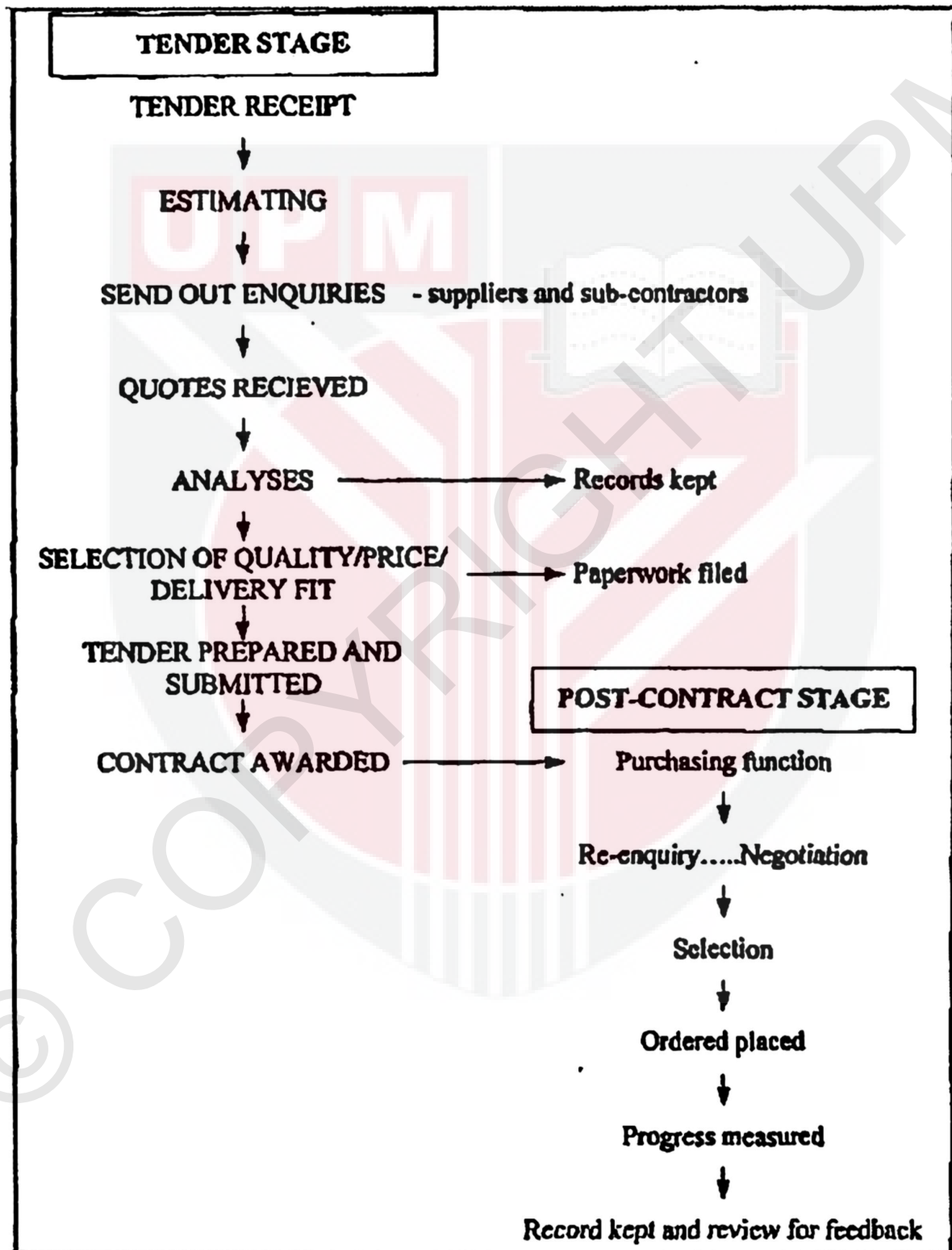


Figure 2-1: Typical Purchasing Procedure (source: Canter, 1993)

2.4.1 Problems of Material Management

The performance of a project might be severely influenced by the poor handling and management of materials on construction sites (Ogunlana, Promkuntong, & Jearkjirm, 1996). Dey (2001) had summarized the major issues relating to materials management, as shown below:

- Receiving materials before they are required, causing more inventory cost and chances of deterioration in quality.
- Not receiving materials at the time of requirement, causing loss of productivity
- Incorrect materials take-off from drawings and design documents
- Subsequent design changes
- Damage / loss of items
- Selection of type of contract for specific materials procurement
- Vendor evaluation criteria
- Piling up of inventory and controlling of the same
- Management of surplus materials

In addition, the use of paper-based work during the construction process for conventional construction methods will produce excessive paperwork and causing poor materials management in construction project. It also contributes to problematic, error-prone and inefficient in the recording and exchanging information of materials component within a supply chain (Zakeri, Olomolaiye, Holt, & Haris, 1996).

2.4.2 Information Communication Technology (ICT) Implementation in Material Management

According to Bjork (1997), ICT are electronic machines and programs including computers and the software, other devices like the telephone, the photocopying machine and the telefax for processing, storage, transfer and presentation of information. The development of ICT in construction industry greatly improve the efficiency of information transfer (Kasim, *Improving Materials Management Practices In Construction Projects*, 2012).

The implementation of ICT in material management could facilitate the effective and efficient control of materials of construction project. For instance, software such as Microsoft Excel and Lotus 1-2-3 are commonly used in estimating cost for material management (Sun and Howard, 2004). Also, Internet is widely used for electronic mail (e-mail) and electronic commerce including electronic invoicing, payments and receipt of materials process (Harris and McCaffer, 2001). Contractors have to get rid of the conventional means of materials management that dominated by paper documents such as drawings and specifications and emerge the sophisticated or innovative tools and techniques to improve efficiency in procurement and quotation activities.

Construction Software (2005) has listed out some software that can support construction activities including material management. They are as listed below.

- **Construction Materials Management System** – link engineering, construction accounting, vendors and other critical functions to manage the procurement, warehousing, delivery and reporting;
- **Material Management System QMS** – system for managing all phases of material management process;

- **Estimate Builder – estimate materials and labor quickly and accurately**

2.4.3 Barriers of ICT Implementation

According to the case studies done by (Kasim, 2011), the main barriers that the industry think are stopping them from ICT implementation can be summarized into four categories, which are people, cost, supplier issues, and profit. Among these four categories, cost issues are the most critical barrier. It refers to the high cost required for the ICT implementation in their projects. Contractors cannot afford to cover the implementation cost incurred, which include the staffs training cost, equipment and software purchasing cost, and also the maintenance cost.

This situation is worsened when the return of investment is uncertain. Contractors doubt that their investment in ICT implementation will give extra profit to their company. The last barrier is on the suppliers, where contractors claim that some of their suppliers unable to cope with and provide their service to the ICT transformation in material management process.

2.5 Summary

Construction industry is one of the most information intensive industry in the world. Bulks of information flow occurs every day during the construction phase of a project. The types of essential information required at construction sites can be categorized into a few groups, which consists of Request for Information, Material Information, Equipment Information, Cost Information, Site, Schedule and Construction Information, Quality Control / Quality Assurance Information and Safety Information. However, there is no survey that had been conducted directly on the issue of information management at construction project in Malaysia. Hence, there is a need of planning a survey in order to further investigate this issue in this country.

Besides that, it had been proven by many researches that ICT tools can assist and improve the information management of construction industry. Therefore, literature review had been done on this topic as ICT implementation is one of the potential solution for the information management issue. It was found that the adoption of ICT tools for example BIM had practically benefited the industry. It assists the industry players in managing the structural information, the site and schedule information, the material information and also the costing information of the project. However, the implementation of IT tools (BIM) in AEC industry of Malaysia especially those Small, Medium enterprises (SME) is not as satisfied as expected. It had been determined that there are barriers that are stopping the industrial players from implementing IT tools in their organization. The top barriers of the issue are the cost and time factor. Part of the industry players are unassured that whether their investment on BIM is profitable or not.

One of the example of information required in construction jobsite is material information. The material management process in construction project include of

planning, procurement, logistics, handling, stock and waste control. Improper management of these processes will create issues such as receiving material at the wrong timing (earlier or later), incorrect material take-off, damage or loss in material and etc. Also, the application of traditional paper-based method of management too will reduce the productivity and efficiency of the construction companies. Therefore, implementation of new technologies especially ICT such as software, Internet, computer based system should be done to prevent all these issues. However, similar to the situation of implementing BIM, there are barriers that are stopping the industry to embrace the ICT in their projects. These barriers are mainly the cost factor, staff compatibility factor, profit factor and the factor of suppliers' incapability to cope with the ICT transformation. As this is one of the alternative solutions to address the issue of information of management, market survey is required in order to further investigate the current practice attitude of the population towards the ICT implementation in managing material information in their construction projects.

Therefore, by using these variables found from literature review, a questionnaire survey will be conducted to achieve the objective (2) stated in Chapter 1. Also, questions will be asked in order to determine the market requirements and opinions on the ICT tool that will be designed to address the information management issue.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter intends to explain the methodology designed for the research topic in order to achieve the objectives of this research, which are (1) To identify the types of information required by contractors in construction project during construction phases in Malaysia (2) To identify the types of information that is not being properly managed in jobsite during construction phase and (3) To propose an alternative solution for small construction company (contractors) to manage and organize the selected types of information. Generally, the methodology had been staged into three phases, which consists of preliminary phase, data collection phase, and data analysis phase.

The preliminary phase is where the initial desk study has been conducted to gather the existing information of the research topic in order to provide a better understanding about the title. After all the information has been collected and interpreted, they will be used as the fundamental ideas to design the questionnaire, which is a method of data collection to obtain answer for the stated research questions and hypothesis. However, as the raw data obtained might be invalid due to several reasons, data analysis is a must to eliminate and filter the raw data, and to draw conclusions regarding the research questions of interest.

3.1 Preliminary Phase

The sole purpose of this phase is to gather all the information available for the research title which is the effective information management for small time contractors during construction phase of a building project. In order to achieve that, literature review has been conducted. Information has been collected from different sources of publications which can include internal company information, relevant trade publications, newspapers, magazines, annual reports, company literature, on-line databases and any other published materials (Statpac, 1997). This phase is very vital to provide understanding on the information management applied in construction industry all around the world.

Also, the problem statements and objectives as stated in Chapter One of the research have been established and proven at this phase through the literature survey. Besides, the first objective of the research has been achieved as well where the types of information required at construction jobsite are obtained from a published journal written by Ballan & El-Diraby, (2011).

3.2 Data Collection Phase

Data collection is the process of collecting information on desired variables in an established systematic way, which then enables one to answer relevant questions and evaluate outcomes. In order to achieve the targeted objectives, a structured questionnaire survey will be mailed to the target sample. A stamped, pre-addressed return envelope will be attached together with the questionnaire to ease the respondents for returning the set of questions. Mailing method of data collection is suitable when conducting surveys on sample who comes from a wide geographic area which is as handled in this research. The structured mailed questionnaire survey method is adopted by referring to some similar research design conducted to the construction industry, especially to the contractors which is also the target sample of this research. Some of the examples of researches that adopted questionnaire survey are shown in the following page.

Table 3-1: Summary of methodology used by some researchers.

Author (year)	Variables of research	Method used	Target sample
Assaf et al. (1995)	First phase: Causes of delay Second phase: Frequency of occurrence and degree of severity for the causes of delay	First phase : Literature review and Interview Second Phase: Questionnaire	Contractors, architects/engineers (A/Es), Public owners
Sambasivan and Soon (2007)	The causes and effects of construction delays	Questionnaires	Contractors and consultants
Long et al. (2004)	Issues relating to large construction projects focusing on the problems experienced	Questionnaires	Professionals involved in large construction projects
Alaghbari et al. (2007)	To identify major causes of delays construction projects in Malaysia	Questionnaires	Government bodies, main contractors, consultants and developers

3.2.1 Questionnaire Development

The questionnaire form for this research has been prepared base on the information gather from the literature review. Also, it is important that the questionnaire be designed properly to satisfy its intended purposes (Constructing Effective Questionnaires, 2006). Therefore, a step-by-step guide to develop an effective questionnaire has been used to structure the questionnaire for this research. The summary of the guide is as described in the following section.

a) Determine the purpose

The purpose of the questionnaire must be predetermined before constructing the questionnaire. For this research, there are a few information that need to be gathered through the survey, which include (1) the respondents' background such as the respondents' post, representing firm, year of experience in the field and the contact information, (2) the types of information that are poorly managed in the construction project, (3) the current practice of information management in the industry, (4) the opinions of the respondents to the implementation of BIM in the industry, (5) suggestions or desired features of IT tools to manage the information. All these information are not available from existing sources and thus questionnaire survey is necessary to be conducted.

b) Define target respondents

The target population for this study is the registered Grade 5 building construction contractors in Selangor area. According to CIDB Malaysia, there are total of 791 nos. of contractors of this grade. However, it will be very costly and time-consuming to conduct the survey to all the members in the population. Therefore, Slovin's formula will be used in order to obtain the appropriate sampling size that can statistically represent the entire population. Slovin's formula is appropriate to be used when the behavior of the target population is undetermined.

Slovin's formula;

$$n = \frac{N}{1 + N(e)^2}$$

Where:

n = sample size

N = total population

e = margin of error (confidence level = 90%)

By using the population number, $N = 1200$ and margin of error, $e = 0.1$, the sample size of this research is calculated as shown below:

$$n = \frac{1200}{1 + 1200(0.1)^2}$$

$$n = 92$$

The sample size obtained is 92, and it is rounded off to 100 as the bigger the sample size, the better the sample can represent the population and thus the higher the validity

of the study. After the sample size has been determined, simple random sampling method is used to select the target sample, which means the 100 nos. of samples are randomly selected from the population. The contact information of the samples can be obtained from the CIDB Malaysia website.

c) Choose Measurement scale and scoring - Likert Scale

A Likert scale is the sum of responses on several Likert items. A Likert item is a statement that the respondent is asked to evaluate by quantifying the item into any kind of subjective or objective dimension. The Likert items must exhibit both “symmetry” and “balance”, where symmetry means that they contain equal numbers of positive and negative positions whose respective distances apart are bilaterally symmetric about the “neutral”/zero value while balance means that to the distance between each candidate value is the same, allowing for quantitative comparisons such as averaging to be valid across items containing more than two candidate values (Burns & Bush, 2007). The Likert Scale is used to show the level of agreement/disagreement for this study as shown below:

1 = strongly agree

2 = agree

3 = neutral

4 = disagree

5 = strongly disagree

d) Conduct Pilot Test

It is important to ensure that the questionnaire developed is appropriate for the respondents, so that the answers obtained are valid and reliable. Therefore, pilot test will be conducted to a group of people who are similar to the respondents. Feedbacks will be collected from them to improve the unclear questions or procedures and detect errors beforehand. The group of people for pilot-testing include of civil engineering students, some lecturers, and some seniors who has graduated and join the industry. The steps listed below is used for the pilot test.

- 1. Observe the participants throughout the test. Disallow them to interfere throughout the test.**
- 2. Take note of any problems arise during the test. This should include under what circumstances problems arise, and how the person attempted to resolve the problem. Also, the reaction of the participants while doing the test has to be observed.**
- 3. Ask questions to clarify why and what the participants are doing. The questions should help to make changes.**
- 4. Allow participants to make notes while doing the test. It will likely get confirmation of problems observed as well as some on-the-spot thinking which cannot observe very easily.**
- 5. Make sure the participants complete the entire questionnaire.**

There are several elements to check for the pilot test (Taylor-Powell, 1998):

- 1. Does each question measure what it is supposed to measure**
- 2. Are all the words understood**
- 3. Do all respondents interpret the question in the same way**
- 4. Are all response choices appropriate**
- 5. Is the range of response choices actually used**
- 6. Do respondents correctly follow directions**
- 7. Does it create a positive impression that motivates people to respond**
- 8. How long does it take to complete**
- 9. Does it collect the information required**

e) Choose the Methods of Reaching Target Respondents

The method used to distribute the questionnaire to the respondents are:

- ✓ Hand pass questionnaires**
- ✓ Mailed questionnaires**

A small portion of questionnaires are delivered to the target respondents through hand passing. This includes those companies that are located nearby the student's house.

The reason of using this method is to increase the response rate of the survey. Mailed method is used for the remaining companies where a stamped, pre-addressed return envelope will be attached together with the questionnaire to ease the respondents for returning the set of questions.

3.3 Data Analysis Phase

This phase is where all the data collected from the questionnaire survey are analyzed and the results are extracted to be discussed in Chapter 4. After eliminating the void results, the raw data from the accepted surveys will be inserted into Statistical Package for Social Sciences, SPSS. The data is first checked for its reliability. Then, descriptive statistics such as mean, standard deviation and percentages will be obtained. For the data that consists of comparison of the means of a normally distributed interval dependent variable for two independent groups, an independent samples t-test will be conducted to verify the difference in mean value is statistically significant.

3.3.1 Reliability Test – Cronbach’s Alpha Reliability Coefficient

Reliability is a measure of how consistent the results of using a measurement instrument (i.e. questionnaire) will be. Cronbach’s alpha is used to check the reliability of the Likert scale used in the questionnaire. The test can be done using the SPSS statistic software. The acceptable values of alpha have been discussed by many statisticians, mostly range from 0.70-0.95. The classification for the Alpha’s value is tabulated as below and used as standard reference for this survey (Nunnally & Bernstein, 1994), (Bland & Altman , 1997), (Devellis, 2003).

Table 3-2: Categories of Internal Consistency for Various Group of Cronbach's Alpha.

Cronbach’s alpha	Internal consistency
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

3.3.2 Univariate Analysis

Univariate analysis refers to the examination across cases of one variable at one time. There are three major characteristics of a single variable that statisticians tend to look at, which are the distribution, the central tendency and the dispersion. For this research, univariate analysis will be done on those variables that are independent and not related with each other variables. The characteristics that will be determined are depend on the level of measurement for the variables. Nominal level of measurement is where the numbers in the scale are appointed as labels and have no specific numerical value or meaning, while for interval level of measurement, the scale allows for rank order by which the data can be sorted, and the distance between attributes does matter. Frequency distribution and central tendency will be calculated for the nominal scale while only central tendency will be determined for interval level of measurement.

Frequency distribution is a table that displays the frequency of various outcomes in a sample. Each entry in the table contains the frequency or count of the occurrences of values within a particular group or interval, and in this way, the table summarizes the distribution of values in the sample.

The relative frequency percentage of each outcome in a sample can also be determined by using the formula shown below.

$$f_i = \frac{n_i}{N} = \frac{n_i}{\sum_j n_j}$$

Where f_i is the relative frequency of outcome i ;

n_i is the number of occurrence of outcome i ;

N is the total number of occurrence for all the outcomes in the sample.

Central tendency of a distribution is an estimate of the “center” of a probability distribution (Weisberg, 1992). The common measures of central tendency are the arithmetic mean, the median and the mode. The description of these measures are as shown below.

- Arithmetic mean – the sum of all measurements divided by the number of observations in the data set.
- Median – the middle value that separates the higher half from the lower half of the data set.
- Mode the most frequent value in the data set.

The used of univariate analysis is found in the research done by (Tsado, 2014) where relative frequency percentage is used to analyze the data on how equipment maintenance has been handled in selected construction companies. Also, the method of analysis is applied by (Sawalhi, 2012) where the central tendency (mean) and the relative frequency percentage are used to analyze the data on the importance of knowing materials waste percentage and the benefits of implementation of materials management software on construction projects. This shows that the method of analysis is practical for the social research in construction industry.

3.3.3 Bivariate Analysis

The difference between univariate analysis and bivariate analysis is it allows researchers to analyze the relationship between two variables to test simple hypothesis of association and causality. This method of analysis will be conducted to determine the relationship between the implementation of ICT and the effectiveness of material management. The mean value of effectiveness of material information will be compared between those who implement ICT in their company and those who don't. To determine whether the results are significant enough to truly make a connection, statistical significance will be checked by using the independent t-test with confidence interval of 90%. The test will be run using the SPSS statistic software (Babbie, 1989).

3.4 Summary

In short, a set methodology had been proposed in order to achieve the objectives and goals of this research. First of all, the problem of the research, which is the inefficiency of information management in construction industry will be identified through literature reviewing. After that, the topic, objectives, and significant of this study will be decided. Desk study of the problem will then be conducted through literature review, in order to gather all the available information of the issue. Next, the current practice and issues that are facing by the industry will be determined by conducting a questionnaire survey towards the sample respondents that are extracted from the target population. Given a limited response time, the returned questionnaire will then be analyzed by using univariate and bivariate analysis. The result of analysis can then be used as a reference and direction to propose and develop a system to address the information management issue.

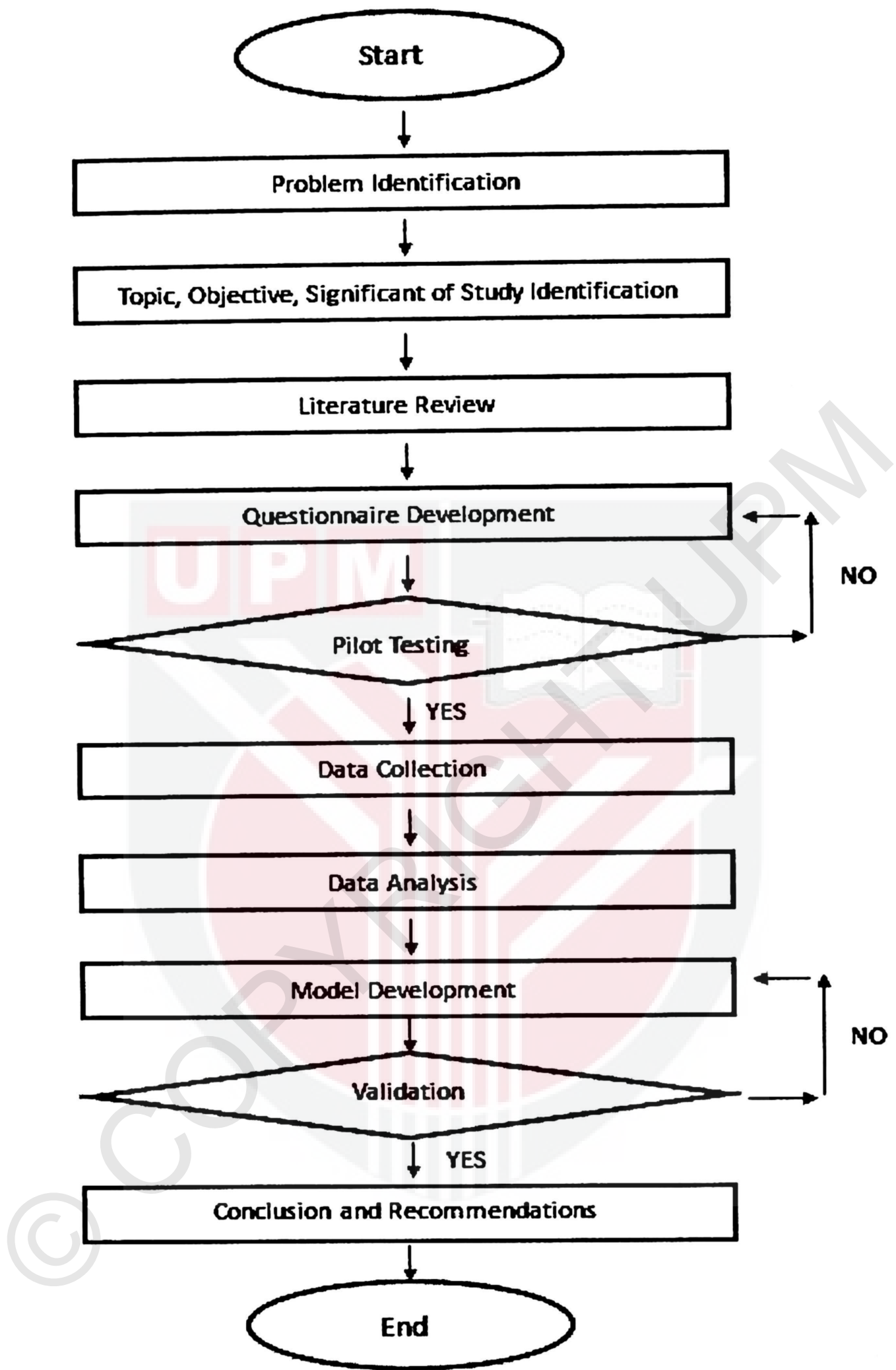


Figure 3-1: Flowchart of Methodology.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter will describe and discuss the result of the structured questionnaire survey conducted for the research. The main target of this survey is to achieve the second and third objectives of the research, which are:

1. To identify the types of information that is not being properly managed in jobsite during construction phase.
2. To propose an alternative solution for small construction company (contractors) to manage and organize the selected types of information.

As discussed in Chapter 3, a total of 100 copies of questionnaires have been distributed to the selected Grade 5 building contractors in Selangor area. Given the response time of a month, a total of 38 copies have been replied, yielding the 38% response rate base on the total distributed surveys. The analysis and discussion of this outcome will be shown in the following section. For better comprehension, this chapter will be structured into three sections according to the sections in the questionnaire. Each sections of the survey are targeted to achieve different objectives of the research.

Section 1: To identify the demographic information of the respondents.

Section 2: To achieve objective (1).

Section 3: To achieve objective (2).



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4.1 Section A: Respondents' Background

The target respondents of the survey are 100 randomly selected Grade 5 building contractor companies in Selangor area. Within a month, total of 38 questionnaires were replied. This number of respondent reduced the confidence level of the survey from 90% to 84%. However, according to Saunders et al., (2011), the response rate within the range of 30-50 percent is reasonable for delivery and collection of questionnaire. William Gosset, a statistician and Head Brewer for Guinness, in an article published under the pseudonym Student concluded that *"with samples of 30 ... the mean value [of the correlation coefficient] approaches the real value [of the population] comparatively rapidly."* (Student, 1908) Therefore, the response number of 38 for this survey is reliable to represent the population.

Demographic analysis has been done to the respondents, and the results are tabulated in Table 1. Among the 38 respondents, 19 (50%) of them hold the position of Project Manager / Deputy Project Manager, 16 (42.1%) of them are Engineers and 3 (7.9%) of them are Quantity Surveyors. Therefore, all the 38 respondents can be considered as qualified respondents to answer the survey as information management at jobsite is within their work scopes.

Table 4-1: Respondent's Post.

Position	Frequency	Percent	Valid Percent	Cumulative Percent
Project Manager / Deputy Project Manager	19	50.0	50.0	50.0
Civil Engineer / Project Engineer / Site Engineer	16	42.1	42.1	92.1
Quantity Surveyor	3	7.9	7.9	100.0
Total	38	100.0	100.0	

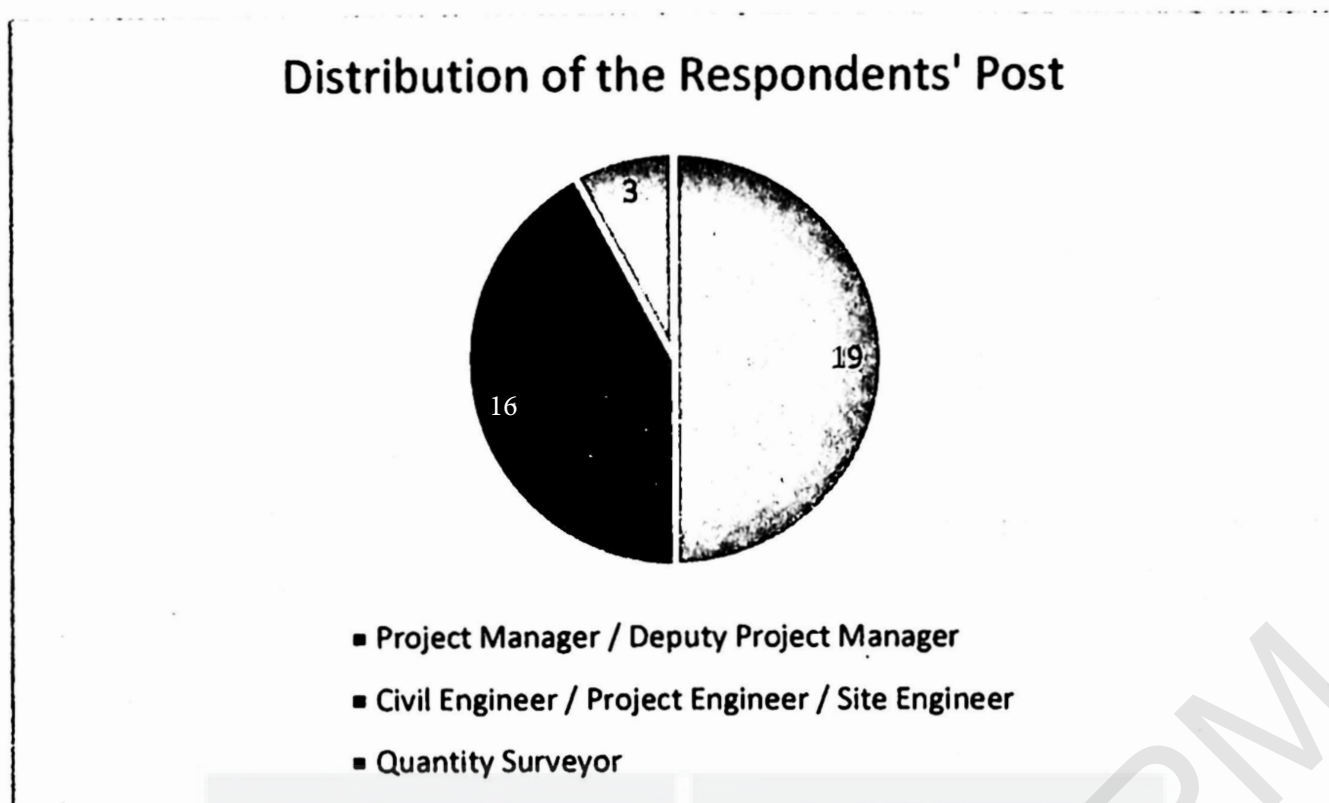


Figure 4-1: Distribution of the Respondents' Position.

The working experience of the respondents have been tabulated and shown in table and bar chart below. The working experience has been grouped into 4 categories, which are 0 to 5 years, 5 -10 years, 10 – 15 years and 15 years and above. The result indicates that most of the respondents have worked in this industry for more than 15 years, which consists of 42.1% of the total respondents. Besides, it can be summarized from the analysis that as much as 72.2% of the respondents have more than 5 years working experience, which increases the reliability of the result as they are considered to be familiar with their work scope.

Table 4-2: Working Experience of respondents.

Working Experience (year)	Frequency	Percent	Valid Percent	Cumulative Percent
0-5 years	12	31.6	31.6	31.6
5-10 years	7	18.4	18.4	50.0
10-15 years	3	7.9	7.9	57.9
15 years and above	16	42.1	42.1	100.0
Total	38	100.0	100.0	

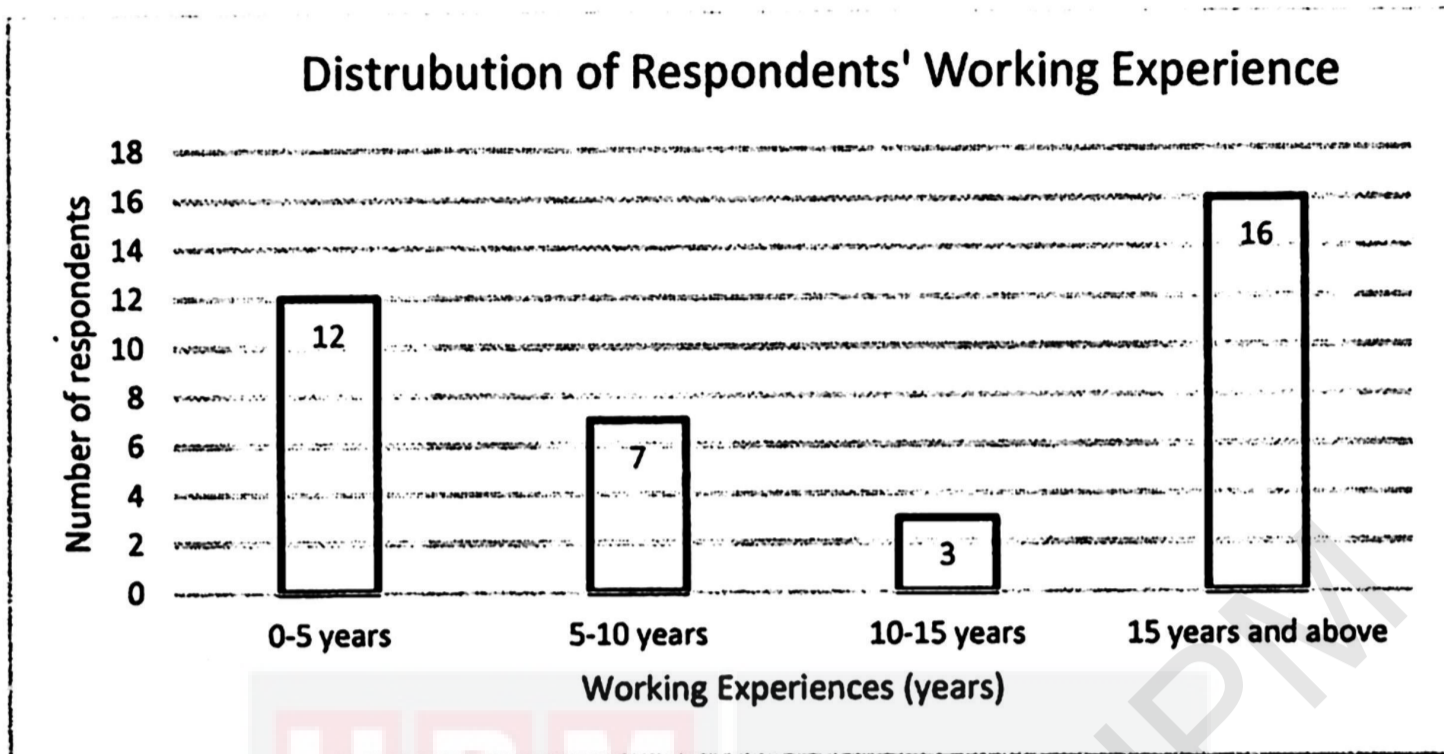


Figure 4-2: Distribution of work experience of the respondents.

4.2 Section B – Effectiveness of Information Management in Jobsite

For the following section, abbreviations will be used for the types of information as shown in the table below:

Table 4-3: Abbreviations used.

Types of information	Abbreviations
Request for Information	RFI
Material Management	MM
Equipment Management	EM
Cost Management	CM
Schedule and Means and Methods	SMM
Jobsite Record Keeping	JRK
Submittals	SMT
Safety	S
Quality Control / Quality Assurance	QCQA

The main target of the research is to solve the information management issue of the industry. In order to achieve that, survey has been conducted to verify the existence of the problem by determining the effectiveness of the information management in the industry. Throughout literature survey, it has been found that 9 types of essential information are required to complete a building construction project successfully. For each type of information, there are subcategories of information. The respondents are required to rate the effectiveness of management for those subcategories of information with the Likert's scale of 1 (Bad) to 5 (Excellent). Then, the median value that represents the respondent's opinion towards the effectiveness of each types of information management can be calculated by using the rates of their subcategories.

After that, the central tendency (mean and median) of the 38 respondents' feedback on each types of information are calculated for two purposes:

- Mean is used to rank the effectiveness of the information management for the 9 types of information.
- Median is used to categorize the effectiveness of the information management.

4.2.1 Reliability Test (Cronbach's Alpha Reliability Test)

Before all the data collected are analyzed, it is important to check the internal consistency of the data to ensure that the set of questions can provide a consistent measurement. The reliability test used for this survey is the Cronbach's Alpha Reliability Test. The acceptable values of alpha have been discussed by many statisticians, mostly range from 0.70-0.95. The classification for the Alpha's value is tabulated as below and used as standard reference for this survey (Devellis, 2003), (Nunnally & Bernstein, 1994), (Bland & Altman , 1997). The test has been conducted separately towards different questions of the questionnaire.

Table 4-4: Categories of Internal Consistency for Various Group of Cronbach's Alpha.

Cronbach's alpha	Internal consistency
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

First of all, the test is conducted to the subcategories of each types of information. The result is as shown in the table below. The lowest Alpha value is owned by the subcategories of Request for Information (0.744), while the highest Alpha value is owned by the subcategories of Schedule, Means and Method (0.946). As the highest and lowest of Alpha values are both within the acceptable range, the questions for subcategories can be said as consistent in measuring the effectiveness of information.

Table 4-5: Alpha values for sub-categories of each information types.

Types of information	Cronbach's Alpha	N of Items
RFI	.744	7
MM	.907	5
EM	.907	5
CM	.883	3
SMM	.946	4
JRK	.916	4
SMT	.948	2
S	.921	2
QCQA	.880	3

Secondly, the test has been done towards the mean values of the 9 categories of information. The result is as shown below. The alpha value for these categories in measuring the overall effectiveness of information management is 0.755, which is within the allowable range. Besides, analysis has been done to determine the Alpha value if any of the item is deleted. Even though the Alpha value increases to 0.768 if the item Request for Information (RFI) is removed, the increase is insignificant (0.013) and both the before and after Alpha value reflect a reasonable degree of reliability, therefore, the RFI is unnecessary to be removed.

Table 4-6: Cronbach's Alpha value for the mean of overall effectiveness of information management.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.755	.755	9

Table 4-7: Cronbach's alpha values if items are deleted.

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
RFI	26.0921	9.552	.152	.293	.768
MM	26.4868	8.480	.353	.295	.746
EM	25.9737	8.364	.551	.381	.717
CM	25.9868	8.534	.436	.420	.732
SMM	26.4342	7.827	.463	.296	.728
JRK	26.1316	7.847	.623	.553	.702
SMT	26.1711	8.260	.421	.574	.734
S	26.1579	7.988	.516	.415	.718
QCQA	26.4605	8.370	.404	.212	.737

4.2.2 Summary of Response toward the Effectiveness of Information Management at Jobsite

After the data collected from the respondents had been check for reliability, it was analyzed as discussed in the previous section. The table below shows the frequency distribution of the median value that represent the average effectiveness for each types of information. For a better illustration purpose, the mean and median value for each types of information had been calculated.

Table 4-8: Frequency distribution of median value of each types of information.

Types of information		Median value					Total
		2.00	2.50	3.00	3.50	4.00	
RFI	Frequency	0	0	23	0	15	38
	Percentage	0	0	60.5	0	39.5	100
MM	Frequency	8	0	22	0	8	38
	Percentage	21.1	0	57.9	0	21.1	100
EM	Frequency	0	2	13	5	18	38
	Percentage	0	5.3	34.2	13.2	47.4	100
CM	Frequency	1	0	17	0	20	38
	Percentage	2.6	0	44.7	0	52.6	100
SMM	Frequency	9	0	18	0	11	38
	Percentage	23.7	0	47.4	0	28.9	100
JRK	Frequency	2	1	18	2	15	38
	Percentage	5.3	2.6	47.4	5.3	39.5	100
SMT	Frequency	1	0	17	2	15	38
	Percentage	10.5	0	44.7	5.3	39.5	100
S	Frequency	4	0	15	5	14	38
	Percentage	10.5	0	39.5	13.2	36.8	100
QCQA	Frequency	7	0	23	0	8	38
	Percentage	18.4	0	60.5	0	21.1	100

The median value calculated for each types of information is used to group the information into different effectiveness categories as shown below.

Table 4-9: Effectiveness categories.

Median value	Effectiveness category
$0.00 \leq \text{Median Value} \leq 1.50$	Bad
$1.50 < \text{Median Value} \leq 2.50$	Poor
$2.50 < \text{Median Value} \leq 3.50$	Moderate
$3.50 < \text{Median Value} \leq 4.50$	Good
$4.50 < \text{Median Value} \leq 5.00$	Excellent

The grouping of the effectiveness for information management reflects that cost information management is the most well managed information among the population. It is the only types of information that falls in the GOOD category of effectiveness. This situation actually explains the importance of cost management in construction industry. While a company's strengths and weaknesses are basically measured by its financial statements, cost information management will usually be paid more attention than other elements as it is the fundamental information of a contractor company. Thus, the effectiveness of cost information management will definitely be higher as compare to the other types of information. While among the MODERATE category, the equipment information management score the highest with median of 3.50, follows by the safety information management with median of 3.25.

Table 4-10: Effectiveness categories for each types of information.

Types of information	N	Median	Average Effectiveness
RFI	38	3.00	Moderate
MM	38	3.00	Moderate
EM	38	3.50	Moderate
CM	38	4.00	Good
SMM	38	3.00	Moderate
JRK	38	3.00	Moderate
SMT	38	3.00	Moderate
S	38	3.25	Moderate
QCQA	38	3.00	Moderate

In order to rank the types of information, the mean value for each types of information had been calculated as majority of the median values are the same and cannot be used to rank the types of information. In order to use the mean value to rank the information, assumption was made that the psychological distance between two successive Likert's scales were all the same with other successive scales.

The mean values and the ranking for each types of information had been calculated and shown in the table below. The ranking of the information reflects that among the 9 types of information, the management of Equipment Information scores the highest effectiveness, with the mean value of 3.51, follows by Cost Information management and Request for Information as second and third respectively.

The trend of result might due to the importance of equipment as one of the key factors for improving contractors' capability in performing their work more efficiently and effectively. In 2011, Cucu states that construction business relies primarily on high utilization of equipment to carry out most of their projects, like construction of

highway and other sophisticated structures. One of the elements of equipment management is to continuously evaluate their equipment records in order to determine what actions are needed for their functionality. By doing this, the risk of major equipment breaks down that will cost a lot for the maintenance or replacement fee can be greatly reduced. This could be the explanation to why the effectiveness of equipment information management among the population ranks first in the list.

In contrast, the material information is the worst managed type of information at jobsite as responded by the respondents. This might be explained by quoting Donyavi & Flanagan, (2009), who says that SMEs tend to reduce costs to be competitive. They tend to win work on low bid price, instead of their technology. Materials are ordered “just in time” to counter the issues of cash flow and storage limitations. Site planning for the off-loading and storage of materials is frequently a random process. In addition, the application of conventional construction techniques which utilize paper-based work during the construction process will produce excessive paperwork and contribute poor materials management in construction projects (Zakeri, Olomolaiye, Holt, & Haris, 1996). Such practices in construction projects will then result in poor material information management. The ineffectiveness of ICT used for managing the material information is also one of the contributing factor to this trend as discussed in the following section.

Table 4-11: Mean and ranking for each types of information management.

Types of information	N	Mean	Ranking
RFI	38	3.39	3
MM	38	3.00	9
EM	38	3.51	1
CM	38	3.50	2
SMM	38	3.05	7
JRK	38	3.36	4
SMT	38	3.32	6
S	38	3.33	5
QCQA	38	3.03	8

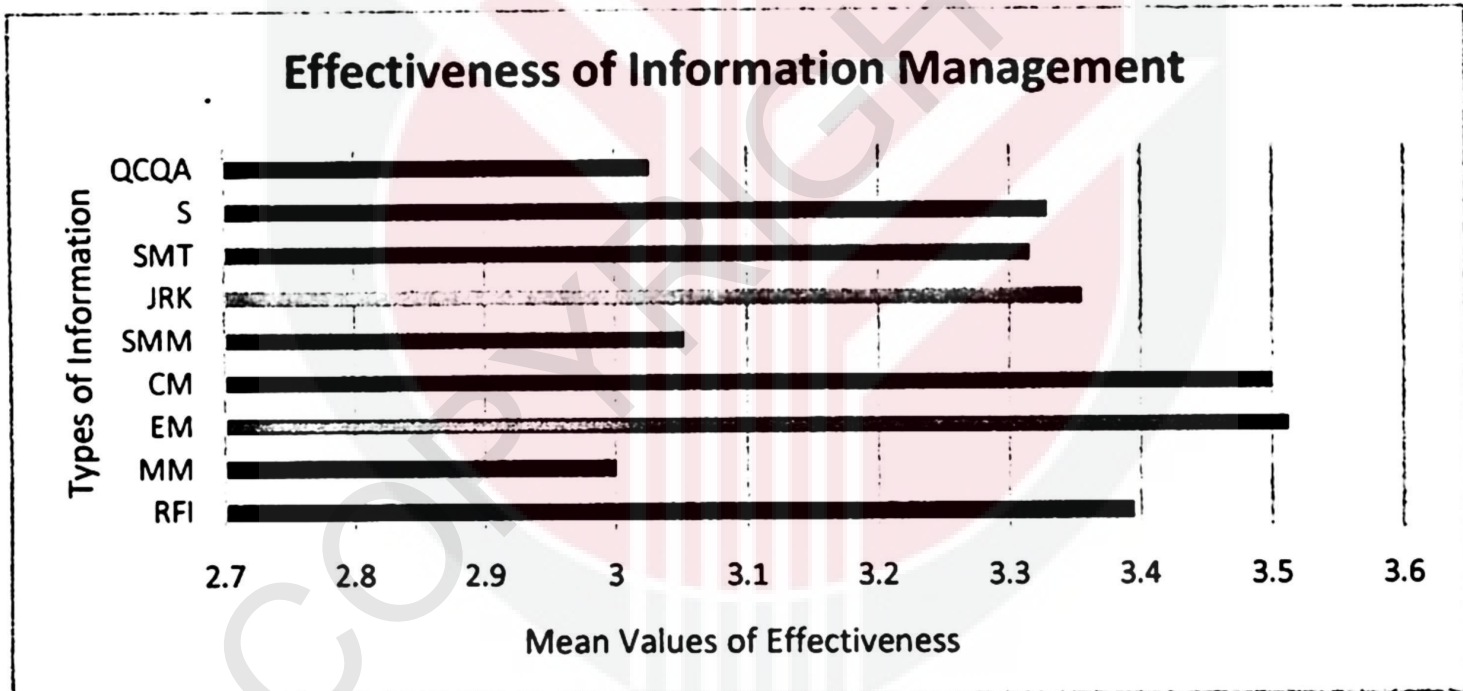


Figure 4-3: Effectiveness of Information Management by mean values.

To conclude, the feedbacks from the respondents reflect that the effectiveness of management is the worst for Material Information and is the highest for Equipment Information and Cost Information. Due to the constraint of time and resources, solution will only be proposed in order to solve the most critical types of information management, which is Material Management.

4.3 Section C – IT Tools for Material Information Management

In order to develop a tool for material information management which fulfill the market's needs, 7 questions have been asked in the questionnaire to study the industry's opinions and requirements of the tool used for material information management. These questions are analyzed and discussed in the following section.

- iv. Question 1: Did your company use any software or IT tools to manage the information listed?

It is important to first determine that whether the company is using any IT tools for information management. The reasons of using or not using IT tools, the advantages and disadvantages of the IT tools if it is applied are all the important aspects to be considered during the development of an efficient and effective information management system.

The frequency distributions for the use of IT tools for each of the information listed in the question are as shown in the chart below. Among the five types of material information, as much as 26 out of 38 respondents managed the information of placing material orders and access to material management using IT tools. The highest percentage of these two types of material information is parallel to the finding of Kasim (2011), who states that materials planning and procurement are the main ICT-embracing processes. According to Kasim, these processes are seen as the most critical start up point of a project, hence extending the greater of ICT adoption. Another possible reason for this might because of other processes such as material logistics and handling require much greater investment in ICT tools such as bar-coding tools for tracking materials, which stops the SMEs from implementing it (Kasim, 2011).

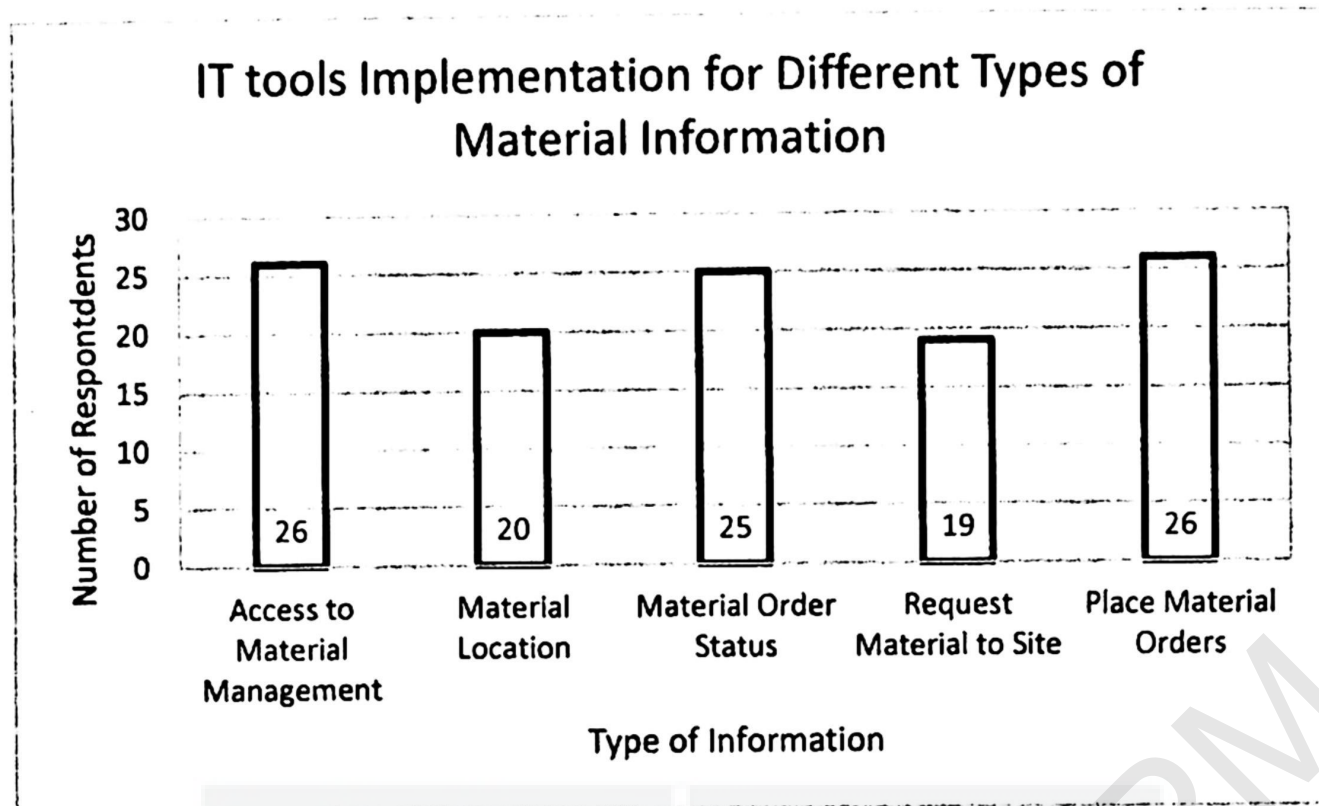


Figure 4-4: IT tools Implementation for Different Types of Material Information.

- v. What kind of software is used to manage material information in your company?

In order to develop an IT tool that can fulfill the market's requirements, survey on the types of software currently used by the market has been conducted. The first choice of the population has been determined to be Microsoft Excel, with the percentage of 63.2%. Other than that, some of the population (21.1%) too prefer to use Structured Query Language (SQL) database to ease their management work. Next, AutoCount is another choice of the population, with percentage of 10.5% of the total respondents. This result is actually similar to the finding of Kasim, (2011) who had conducted a case study on the Information Communication Technology (ICT) implementation for materials management in 5 construction projects located in Johor, Malaysia. Her findings had concluded that Microsoft Excel and Microsoft Project are the most common ICT tools in current industry's practice. The main reason behind this is because these two ICT tools are less costly and thus affordable by those contractors.

Kasim (2011) too had outlined that the lack of awareness to the benefits in ICT implementation among the contractors is another reason for the limited application of ICT tools in material management as. Besides, handling of relatively small to average projects too is stopping the contractors from investing in advanced ICT tools as they are doubt for a good return of investment and thus conferring to the lowest usage of ICT as possible. Hence most of the contractors among the population prefer Microsoft Excel as their tool in managing material information for their projects.

Table 4-12: Software used for material management.

Software used	Frequency	Percentage
Microsoft Excel	24	63.2%
Structured Query Language (SQL) database	8	21.1%
AutoCount	4	10.5%

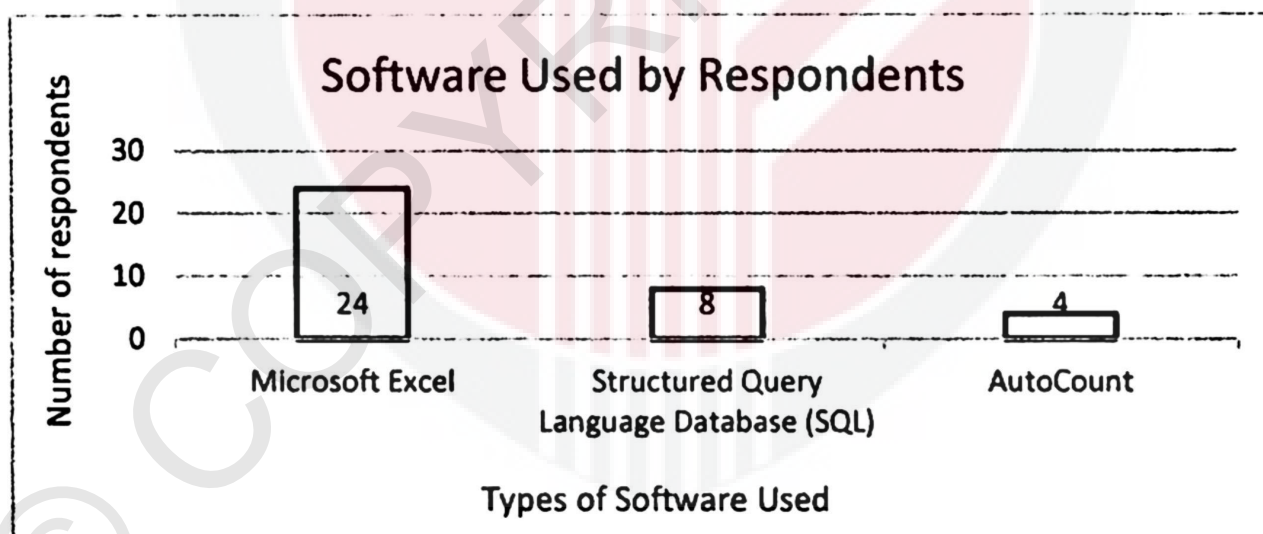


Figure 4-5: Software used for material management.

vi. How effective is the software stated above in managing the information?

The effectiveness of the IT tools has been investigated so that the preferred types of software can be known. It has been found out that as much as 47.4% of the population felt that the softwares that are currently used for material information management is moderate. Only 10.5% of them think that their softwares possess high effectiveness. The average mean effectiveness calculated is 3 out of scale of 5, which is within the category of "Moderate". Therefore, it can be assumed that the softwares in use currently only give moderate effectiveness to the population. The disadvantages of the softwares will be discussed in the next section.

The result also indicates that only an average of 26.3% of the industry do not apply any IT tools in managing the material information, which indirectly shows the importance of IT tools in information management at jobsite. The situation is probably caused by the increasing awareness of the construction players toward the benefits of automating the materials handling process, including increased productivity, better space utilization, higher customer service levels, reduced operating expenses and improved flow of materials. Embracement of ICT in construction project is found to be essential in order to overcome the material management problems inherent within the construction industry.

Also, it had been figured out that the effective implementation of ICT has the huge potential to bring about significant improvements (Kasim, 2011). In order to prove this, comparison has been made between the mean values of effectiveness of material management of those who implemented ICT with those who don't. The result shows that the effectiveness of material management is much lower for those contractors who did not adopt ICT in their project (2.600) compared to those who did (3.077). To show

that the difference between the mean value is statistically significant, independent t-test has been conducted using the confidence interval of 90%. The difference in mean value is proven to be significant as the significant (2-tailed) value is 0.089 which is lower than 0.1 as shown in table below. This reflects that application of IT tools will help to increase the effectiveness of information management in jobsite.

Table 4-13: Effectiveness of the software used.

Effectiveness of Software	Frequency	Percent
Very Low	0	0
Low	4	10.5
Moderate	18	47.4
High	4	10.5
Very High	0	0
No Software	10	26.3
Invalid	2	5.3
Total	38	100.0

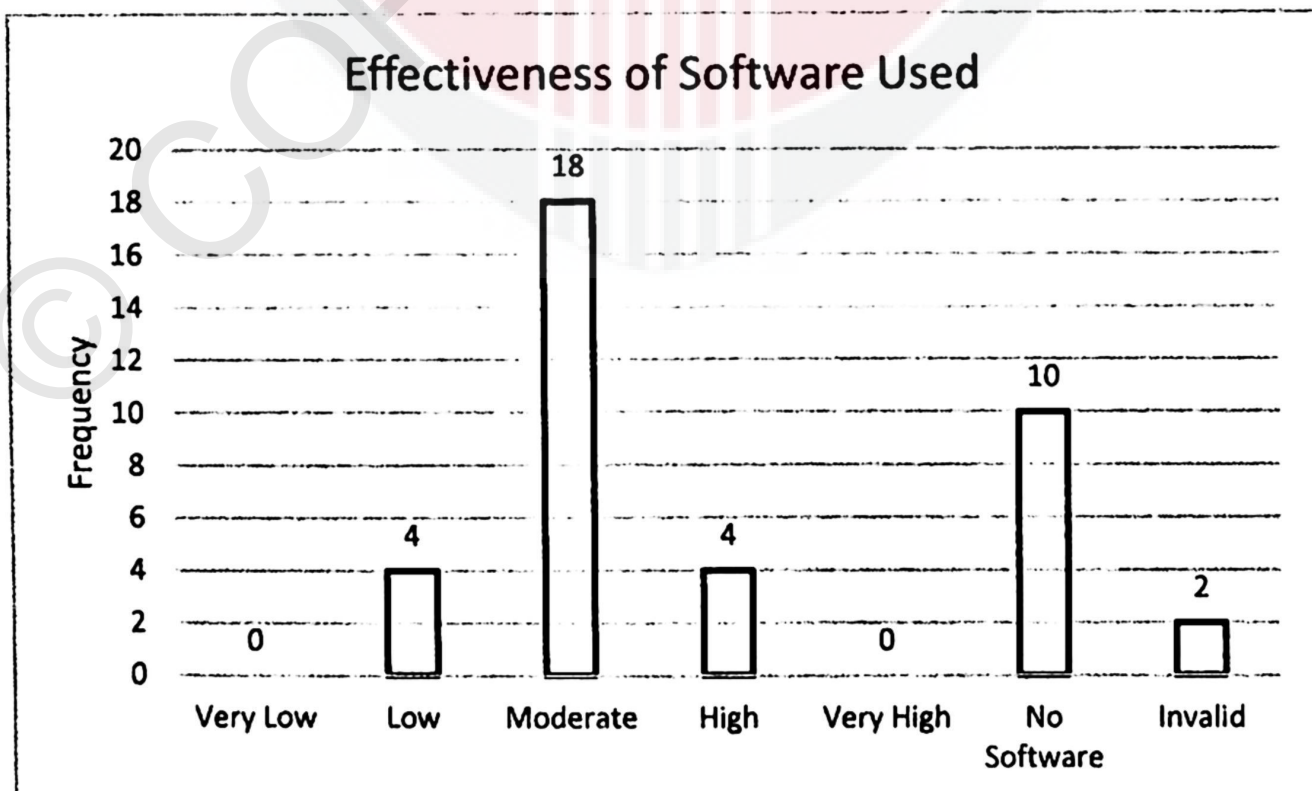


Figure 4-6: Effectiveness of software used.

Table 4-14: Independent Samples T- Test for Effectiveness of Material Information Management and Implementation of ICT

	Software	N	Mean	Std. Deviation	Std. Error Mean
Effectiveness of material information management	Yes	26	3.0769	.74421	.14595
	No	10	2.6000	.69921	.22111

Table 4-15: Independent T-test for Equality of Means

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	90% Confidence Interval of the Difference	
							Lower	Upper
Effectiveness of material information management	Equal variances assumed	1.75	34	.089	.48	.27259	.01599	.94
	Equal variances not assumed	1.80	17	.089	.48	.26494	.01660	.94

vii. What are the advantages of the software?

This question is set to determine the advantages of the software currently used by the respondents. The main advantage of those softwares that attract the respondents is “easy to learn” whereby 65.8% of the respondents agree to it. This result indirectly indicates that the complexity of the IT tool is one of the major factors that will affect implementation of IT tool in construction industry. Similar reason have been given by SMEs in construction industry when asked by Anuar & Zainal Abidin (2015) on implementation of Building Information Modeling (BIM) where they claim that their

technical staffs are not ready to be trained for that and they have little or no knowledge about it. Memon (2014) who had conducted a survey on the implementation of BIM in Malaysia too summarize that “lack of competent staff to operate the software” is the most significant barrier in BIM adoption in construction industry. Therefore, it is important to consider the users’ experience when designing the material management system as a complicated system will definitely a turn down to the users. The system interface and function must be easy to be perceived, learned and applied by the users in order to increase the marketability of the proposed system.

In addition, the cost issue is another factor to be emphasized on during the model development as 63.2% of the respondents actually agree to low cost as the advantage of the software they are currently applying. Apparently, this issue is the common factor for ICT implementation in any industry, for example, BIM (Memon, 2014), (Gerges et al., 2017). This factor will become more critical for SME’s contractor companies who tend to reduce production cost to be competitive. Due to the relatively smaller project size, they tend to reduce the cost of construction by minimizing the expenditure on ICT as they doubt on the return of investment of ICT implementation (Donyavi & Flanagan, 2009).

Generally, the result of the survey indicates more than half of the population agree that these all advantages are important for an IT tool to be used in information management. Therefore, the four main elements to be considered when developing an IT tool are: (1) Easy to learn, (2) Reasonable cost, (3) Effective information recording, and (4) Effective information retrieval.

Table 4-16: Advantages of software used.

No.	Advantages	Frequency	Percentage (out of 38 respondents)
1	It organizes the information and eases information retrieveing	20	52.6
2	It keeps good records of the information	21	55.3
3	Easy to learn	25	65.8
4	Low cost	24	63.2

viii. What are the disadvantages of the software?

As the main purpose of the IT tool development is to improve the material information management of the population, the disadvantages of the tools in use have to be determined so that the same mistakes can be optimized. The result reflects that the main disadvantage (65.8%) of the softwares used by the population currently is they are not user-friendly. Some of the respondents claimed that tedious work is required for data entry using the software, which turns down the satisfactory towards the software. Same issue is faced in healthcare industry as claimed by Ross, et al. (2016), that complexity factors such as software and hardware that are difficult to use, slow system performance and the work involved in transferring records between two systems, will influence the implementation of systems in healthcare settings. The effective solution for this is to involve end users in the design and development process and also provide guides and technical assistance to the end users. Hence, the end users' opinions must be considered when developing the material management system. Technical support and demonstation of using the system must be provided so that the users can understand, learn and use the system in the shortest possible time.

Besides, as much as 52.6% of respondents claimed that the softwares in use are not

demanding by customers. Respondents think that their investment in ICT does not directly give them any edges in competing with others competitors who do not implement that. In another word, adopting those software does not directly increase their profit and thus they decided to minimize the investment on it.

Furthermore, those softwares are also said to be required too much work to be implemented by 36.8% of the population. Companies have to spend time and money to train their staffs and prepare the equipments needed at the initial stage in order to implement the IT tools for their project. The financial status of some small scale projects might be burdened because of this extra expenditure, which thus impeded the software implementation in SMEs. (JBIM, 2007).

Table 4-17: Disadvantages of the software used.

No.	Disadvantages	Frequency	Percentage	Ranking
1	The initial upfront expenditure is too costly	7	18.4	5
2	Require too much dependency of specialists	4	10.5	7
3	Require excessive work to implement	14	36.8	3
4	The software is too complicated to use	6	15.8	6
5	Do not required by customers	20	52.6	2
6	Tedious work for data entry (Not user-friendly)	25	65.8	1
7	Reliability of the software	10	26.3	4

ix. Do you prefer to use any IT tools or software in managing those information?

The next question asked is to determine which types of material information are preferred to be managed by using IT tools. From the response of the survey, it can be seen that more than 70% of the respondents prefer to use IT tools to manage all of the material information listed except for the material location information with 68% of supports from the population. Therefore, all these types of material information will be considered as the important elements when developing the IT tool. This result is an indication showing that the local SME's contractor companies are starting to recognize the benefits of IT adoption in construction projects. They start to agree to the fact that the uses of IT tools can increase their productivity and efficiency of work. Their attitude in this issue shows that development of a material information management system will be an effective solution for the material information management problem.

Table 4-18: Types of material information that are preferred to be managed using IT tools.

Types of material information that preferred to be managed using IT tools	Frequency	Percentage
Access to Material Management	36	95
Material Location	26	68
Material Order Status	33	87
Request Materials to Site	29	76
Place Material Orders	31	82

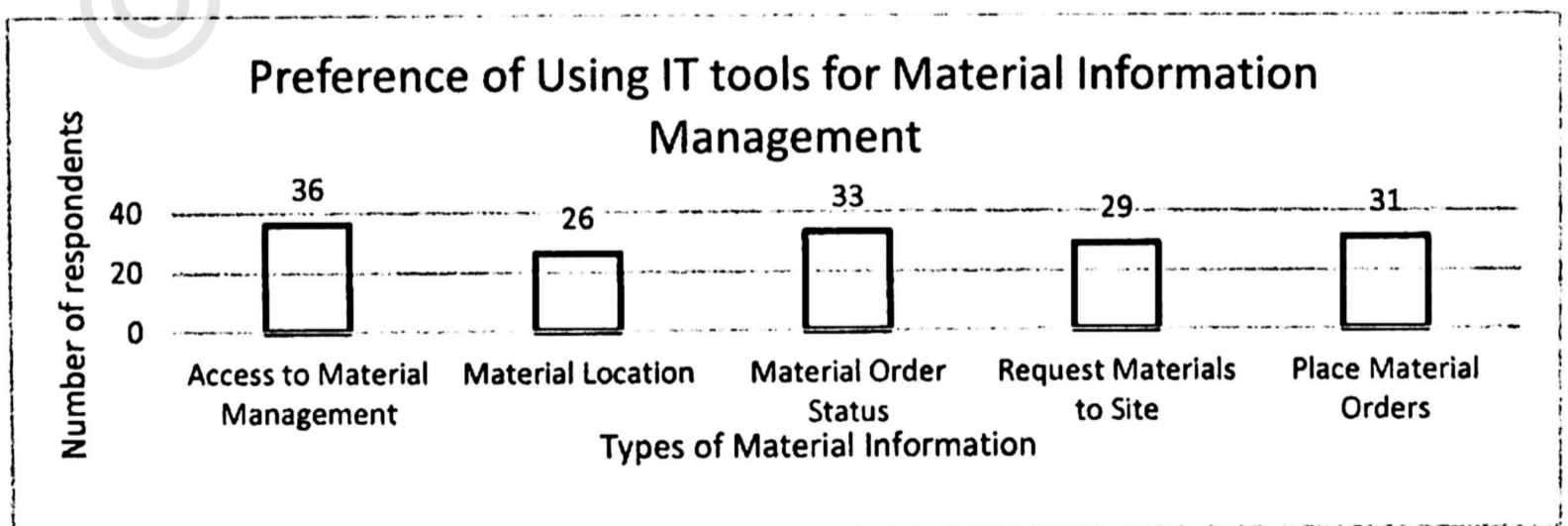


Figure 4-7: Preference of using IT tools for material information management.

- x. In your opinion, which of the following features are useful for managing material information?

The last question of the survey is to determine the expected features of the IT tools by the respondents. The response for this question as shown in the table below will be used as the fundamental concept of developing the IT tool. According to the ranking of the response, the main function of the tool will be (1) record the quantity of the material left and record the suppliers or vendors, (2) record the price of the material, (3) comparison of the vendors or supplier base on the records while the functions that will be least considered are (1) Indicate the storage space available and record the expiry date of the material, (2) Record the location of the material, and (3) Record the specification of the materials. The trend of the result might because of the respondents believe that ICT can do a better job in addressing those material information management elements, compare with the conventional methods or the methods they are currently practicing. The documentation and information tracking process will be shortened and the record can be tracked easily even if the record is dated many years back by using an effective ICT tool. The paperwork and time spending on material management will also be greatly reduced. Another reason for this situation is that ICT can enhance the budget controlling and material procurement work, especially in pricing of products.

In a nutshell, ICT transformation is deemed vital especially in the area of material procurement and delivery, material information tracking, material cost effectiveness and materials handling. Hence, the development of the material information management system will be done toward these directions.

Table 4-19: Expected features of the proposed information management system.

No.	Expected features	Frequency	Percentage	Ranking
1	Record the quantity of the material left	37	97.4	1
2	Record the location of the material	16	42.1	6
3	Record the price of the material	36	94.7	2
4	Record the suppliers or vendors	37	97.4	1
5	Comparison of the vendors or suppliers base on the records	35	92.1	3
6	Record the specification of the materials	20	52.6	5
7	Indicate the storage space available	15	39.5	7
8	Record the expiry date of the material	15	39.5	7
9	Help in determining the optimum ordering and carrying cost	34	89.5	4

4.4 Summary of Questionnaire Survey Analysis

To summarize this chapter, information management is an issue in Small and Medium Enterprises (SMEs) for construction industry. Out of the 9 types of essential jobsite information, only the management of cost information is categorized as “GOOD” while the others are all in the category of “MODERATE”. While for the ranking of the effectiveness of management, the equipment and cost information are both placed at the top. In contrast, material information is the worst-managed information among the respondents. The first objective of the research has been approached in this section where the information that is worst-managed is determined to be material information.

The next section of this chapter is focused on material information management as the second objective of this research is to propose a solution to address the poor management issue in material information. The feedback from the respondents indicate that as much as 73.7% of them have been using IT tools in managing the material information for their projects. Comparison of the effectiveness of material information management has been made between those who use and does not use IT tools in their project, and the result shows that those who use IT tools give higher rate than those who don't. Hence, this actually backs up the proposed solution of developing a system to address the information management issue. Next, the survey has figured out that the software currently in practice are AutoCount, SQL database and Microsoft Excel where Microsoft Excel is the most-used software among them (63.2%). However, the result also indicates that the effectiveness of the software in managing material information is unfavorable as 61.1% of the respondents rate its effectiveness as “MODERATE” or lower. Therefore, it is believed that a more effective and efficient system can replace these software in used and improve the effectiveness of material information management in jobsite. Then, the advantages of those software

have been determined, where most of the respondents are attracted to the “easy to learn” and “cost” factors. The other advantages are such as effective information recording and retrieval. All these factors are considered during the software development as more than 50% of the respondents agree with them. In contrast, the major disadvantages of those softwares are such as not user-friendly, not demand by clients and require too much of work to be implemented.

Questions have been asked on the preference types of material information that the respondents would like to manage using IT tools, and the overall result shows that more than 70% of the population prefer to manage the material order status, placing material orders, access to material management, material location and request materials to site using IT tools. Lastly, the features of the proposed system that are expected by majority of the industry are to record quantity of material left in inventory, record information of suppliers, record the material price, evaluate the suppliers base on the transaction history, calculate the optimum ordering and carrying cost, and record the specification of the materials. All these features will be prioritized to be included in the proposed material information management system in order to fulfill the market requirements.

4.5 Proposed Solution – A Web-Based Material Information Management System

4.5.1 Process of Developing the System

In order to achieve all the objectives of this research, a set of procedure has been planned at early stage as discussed in Chapter 3. This set of procedure has been followed throughout the survey in order to systematically and efficiently resolve the issue of study. A detailed description of what have been done for each stage of the procedure will be described in this section.

1. Problem identification

The very first step of this survey is to identify the problem. This is done by understanding the current issues of the construction industry through the media such as news, journal, internet forums, and conversation with industry players. Then, information management had been chosen to be the direction for this research. Next, student deep dived into this topic by doing literature review and discussion with supervisor. The issue, information management in construction industry had been then figured out with the support of publication.

2. Problem clarification and identification of current practice in the industry

As the same issue might be varied at different location and situation, it is necessary to clarify that the problem does exist in the target population of study. Therefore, a structured questionnaire survey had been conducted to the selected sample. The feedback from the survey can be summarized as follow:

- I. Among the 9 types of information, only one of them is categorized as “Good” in effectiveness of management, while the others fall in the category of “Moderate”.
- II. Equipment Information is the best managed, while the Material Information is the worst managed.

Then, survey had been done in order to further investigate the issue on the worst managed information, Material Information. The survey also targets to investigate the market requirements on the material information system. Questions had been asked on the types of information technology (IT) tool used, the effectiveness, pros and cons of the IT tools, the preference of using IT tools in material management, and the expected features of the material management IT tools. The result of the survey is summarized below:

- I. The material management IT tools that are currently used by the respondents are Microsoft Excel, Structured Query Language (SQL) database and AutoCount.
- II. The outstanding advantages (percentage higher than 50%) of these tools are the information is well organized, the information retrieving is simple and user friendly, the information is well recorded, low cost, and technically simple to use.
- III. The major disadvantages (percentage higher than 40%) of the tools are high initial upfront expenditure, complicated procedure for data entry, and technically difficult to learn.
- IV. The expected features of the proposed IT tool are to record the quantity of the

material left, record the suppliers' information, record the price of material, comparison between suppliers base on previous trading record, determine the optimum ordering and carrying cost, and record the specification of materials.

3. Propose model

After considering all the feedbacks from the respondents, a web based material information management system had been proposed as a solution for the material information management issue in Small and Medium Enterprise (SMEs). The material management system is designed base on the requirement of the industry players obtained from the questionnaire survey. The primary functions are to record material transaction, both procurement and delivery. Also, the system can be used to revise the transaction records and the trading history with suppliers. The detailed description of the system will be discussed in later section.

4. Model test run

This step is necessary to provide stakeholders (the industrial players) with information about the quality and functionality of the system under test. After the system had been designed, trial run had been conducted by the student himself, to assure the functionality of the system. All functions had been tested to ensure that the system is completely working and fit for use.

5. Model validation

In order to ensure that the proposed system did really help to solve the material information management issue in the targeting population, product validation had been done. Student had met up with a number of respondents who were willing to spend their time to test the material information management system. They were first shown and explained on the functionality and features of the system. Then, student demonstrated the steps of using the system to the respondents. Next, the respondents were asked to try the system themselves with the guide of student. Finally, respondents were required to give feedbacks on the performance of the system. Also, recommendations for improvements and future developments were provided by some of the respondents.

Generally, all the respondents were satisfied with the effectiveness of the system in solving the material information management issue in their company. Besides, the respondents were interviewed on the functionality, cost of implementation and technical barriers of the proposed system as these factors had been proven as the stumbling blocks of implementation of IT tools in construction industry. As a result, most of the respondents were satisfied with the functionality of the system in managing material information. The system was said to be practical and user-friendly as the users can pick up in a very short time. Most of them shown their interest to implement the system in their project if the cost of the system is reasonable. Some comments and recommendations were given with the aim to improve the practicability of the system and had been included in the future development section. Therefore, it can be concluded that the system designed and developed had achieved the goal which is to address the material information management issue in construction industry.

4.5.2 Function of the Material Management Tool

Throughout the industry survey, the material information that are concerned by the respondents are the remaining quantity, price, supplier, specification of the material. Therefore, the model has been designed to assist the users on managing these information. The main functions of the system is to record the material transaction information. All the features of the system are as listed and explained below.

1. Record material procurement

For every material procurement made, the users have to record it down using the system. The information required for the transaction are the unit price, quantity and types of the material, supplier information, the location of inventory and the expiry date of the material which is an optional information. In addition, users are provided a space to attach all the relevant documents of the transaction. The detail description for all the information are as shown in the table 4-20.

Steps:

- i. Go to the “Material” tab**
- ii. Select the option “Receive”**
- iii. Click the “add” button at the top right corner of the page**
- iv. Enter the material information (Fill in all the mandatory fields)**
- v. Upload softcopies of all the relevant documents**
- vi. Submit and save**

Table 4-20: Types of information required for materials procurement.

Types of information	Description
Unit price	The price per unit of the material offered by the suppliers.
Quantity	The total amount of each material purchased for each transaction. Units of measurement that are commonly used in construction industry are provided, while users are given the right to add in more units that are not available in the system.
Types of material	The name of the material. For any first-time-purchased material, users have to first input the detail information and specification of it before proceeding to the material procurement record.
Supplier information	The name of the suppliers' company. Users have to first input the detail information of the suppliers before proceeding to the material procurement record for any new interacted suppliers.
Location of inventory	The name of the warehouse/inventory. Users have to first input the detail information of the warehouse before proceeding to the material procurement record for any new located warehouse.
Attachment of relevant documents	Softcopy of any relevant documents of the transaction can be attached. Examples are such as contract documents, purchase order, delivery order, good receive note, tax invoices etc.
Expiry date of material	The expiry date of the material. As not every type of material will expire, this field is set to be optional.
Ordering Point	The critical amount of material left in the inventory. When the quantity drops below this number, the system will notify the users to plan for the next procurement by sending an email to the person in charge.

Setup - Receive

Upload Attachments No file chosen

Branch Code A111 - B1

Detail

Material	Supplier	Warehouse	Quantity	UOM	UnitPrice	Remind Qty	Expiry Date
Not Selected	Not Selected	Not Selected	0	unit	0	0	24/05/2017
Not Selected	Not Selected	Not Selected	0	unit	0	0	24/05/2017
Not Selected	Not Selected	Not Selected	0	unit	0	0	24/05/2017
Not Selected	Not Selected	Not Selected	0	unit	0	0	24/05/2017

Figure 4-9: User interface for procurement transaction recording.

WARNING!!!

MATERIAL LEVEL LOW!!!

Name	: Material A
Quantity available	: xxx unit
Optimum order quantity	: xxx unit
Regular supplier	: ABC supply
Unit price for previous transaction	: RM xxx

You will not know how much it hurts until you ignore me, so you better don't.

Figure 4-10: Template of notification email to remind user about the order point.

2. Request and record material delivery

When there is any request at site to deliver material from the inventory, users are required to request permission for the material transaction through the system. The information required for the transaction are the types of material, the quantity of material to be delivered, and the project that required the material. Only after the request has been approved by the superior, the transaction can be proceeded. The detail description for the information required are as tabulated below.

Table 4-21: Types of material information required for delivery.

Information	Description
Types of material	The types of material to be transferred out of the inventory. Transaction can't be done if the material is unavailable in warehouse.
Quantity of material	The total quantity of material to be transferred out.
Project Information	The detail information of the project that request for the material transfer. Users have to first input the detail information of the project before proceeding to the material transaction record for any new established project.

Steps:

- i. Go to the "Material" tab
- ii. Select the option "Delivery"
- iii. Click the "add" button at the top right corner of the page
- iv. Enter the material information (Fill in all the mandatory fields)
- v. Submit and save
- vi. Approval from the admin
- vii. Delivery work can be proceeded

Setup - Delivery

Branch Code A111 - BI

Detail

Material	Project	Quantity
Not Selected	Not Selected	0
Not Selected	Not Selected	0
Not Selected	Not Selected	0
Not Selected	Not Selected	0
Not Selected	Not Selected	0
Not Selected	Not Selected	0
Not Selected	Not Selected	0

Figure 4-11: User interface for material delivery transaction record (1).

Not Selected	Not Selected	0
Not Selected	Not Selected	0
Not Selected	Not Selected	0
Not Selected	Not Selected	0
Not Selected	Not Selected	0
Not Selected	Not Selected	0

Delivery By

Delivery Ref 1

Delivery Ref 2

Remark

Submit

Figure 4-12: User interface for material delivery transaction record (2).

3. Rate the quality of the material purchase

As stated by Khyomesh, 2011, one of the primary objective for material management is to assure the quality of the material. Therefore, another feature of the system is that it allows users to rate the material purchased. For every transaction made with particular supplier, users can rate the quality of the material purchased with a scale of 1 to 10. In addition, a space is provided for users to jot down any comment towards the product. The function will enable users to revise the quality of material provided by particular suppliers, assisting users to filter out the unfavorable suppliers for future procurement.

Steps:

- i. Go to the “Material” tab**
- ii. Click on the option of “View”**
- iii. Search for the material from particular supplier**
- iv. Click the “Rating” button**
- v. Rate the quality of the material from scale 1-10 provided, additional comment can be added in words**
- vi. Submit and save**

Material - Update

Name: SLIDER
 Name: SUPPLIER1
 quantity: 0
 UOM: units
 unitPrice: 0.00
 expiryDT: 22/3/2017 12:00:00 AM
 rating: 10
 remarks: REMARK

Save Cancel

Figure 4-13: User interface for the rating function.

Materials Inventory

Material Name	Supplier Name	Warehouse Name	Rating (1-10)	Receive Date	Actions
SLIDER	SUPPLIER1	WAREHOUSE1	10	27/3/2017 10:14:09 AM	Rating View
SLIDER	SUPPLIER1	WAREHOUSE1	0	27/3/2017 11:01:42 AM	Rating View
SLIDER	SUPPLIER1	WAREHOUSE1	0	27/3/2017 11:03:14 AM	Rating View
SLIDER	SUPPLIER1	WAREHOUSE1	0	27/3/2017 11:03:14 AM	Rating View
SLIDER	SUPPLIER1	WAREHOUSE1	0	27/3/2017 11:03:14 AM	Rating View
SLIDER	SUPPLIER1	WAREHOUSE1	0	27/3/2017 11:03:14 AM	Rating View
SLIDER	SUPPLIER1	WAREHOUSE1	0	27/3/2017 11:03:14 AM	Rating View
SLIDER	SUPPLIER1	WAREHOUSE1	0	27/3/2017 11:03:14 AM	Rating View

Figure 4-14: The user interface showing the rating of the materials.

4. Trace back the material record

In addition, the system also provides visibility into the source and destination of the material. The information available for reviewing are the supplier information, the quantity left in inventory, the unit price and expiry date of the material, and the quality evaluation of users to the material. Moreover, the system provides a systematic searching feature, where users can sort the items according to the ascending or descending alphabet, or they can even simply type in the name of either material, warehouse, supplier or transaction date to search for the particular transaction record.

Steps:

- i. Go to the “Material” > “Transaction” tab**
- ii. Select the “View” option**
- iii. Sort the items alphabetically or directly search for some particular item (date of transaction, material, supplier, warehouse)**
- iv. Click the “View” button on the particular transaction**

Materials Inventory

Material Name	Supplier Name	Warehouse Name	Rating (1-10)	Receive Date	Actions
SLIDER	SUPPLIER1	WAREHOUSE1	10	27/3/2017 10:14:09 AM	Rating View
SLIDER	SUPPLIER1	WAREHOUSE1	0	27/3/2017 11:01:42 AM	Rating View
SLIDER	SUPPLIER1	WAREHOUSE1	0	27/3/2017 11:03:14 AM	Rating View
SLIDER	SUPPLIER1	WAREHOUSE1	0	27/3/2017 11:03:14 AM	Rating View
SLIDER	SUPPLIER1	WAREHOUSE1	0	27/3/2017 11:03:14 AM	Rating View
SLIDER	SUPPLIER1	WAREHOUSE1	0	27/3/2017 11:03:14 AM	Rating View
SLIDER	SUPPLIER1	WAREHOUSE1	0	27/3/2017 11:03:14 AM	Rating View
SLIDER	SUPPLIER1	WAREHOUSE1	0	27/3/2017 11:03:14 AM	Rating View

Figure 4-15: User interface showing the material available in inventory.

Material Inventory - Detail

Name	<input type="text" value="SLIDER"/>
Name	<input type="text" value="SUPPLIER1"/>
quantity	<input type="text" value="0"/>
UOM	<input type="text" value="units"/>
unitPrice	<input type="text" value="0.00"/>
expiryDT	<input type="text" value="22/3/2017 12:00:00 AM"/>
rating	<input type="text" value="10"/>
remarks	<input type="text" value="REMARK"/>

Figure 4-16: User interface showing the detail information of a particular material.

5. Check the transaction history with suppliers

This feature is to assist the users in evaluating the suppliers during tender process, where they can trace back the previous record with some particular supplier if there is any. The system will show a list of suppliers that have trading record previously, together with the types of material traded, the transaction history (codes), and the rating of the material traded previously.

Steps:

- i. Go to the "Material" tab
- ii. Select "Record Checking"
- iii. Select "Supplier"
- iv. Choose the particular supplier
- v. Check for the transaction history

Information Management System V1.0.0.0 - Production Home Materials Equipment RFI Crsl Safety OCDA Approval System

Search by Supplier

Select Supplier:

Receive Code	Material Name	Supplier Name	Unit Price	Rating
1703-RA11101	SLIDER	SUPPLIER1	0.00	10
1703-RA11101	SLIDER	SUPPLIER1	10.00	0
1704-RA11101	SLIDER	SUPPLIER1	10.00	0
1704-RA11101	SLIDER	SUPPLIER1	102.00	0
1704-RA11101	SLIDER	SUPPLIER1	103.00	0
1704-RA11102	SLIDER	SUPPLIER1	104.00	0
1704-RA11102	SLIDER	SUPPLIER1	105.00	0
1704-RA11102	SLIDER	SUPPLIER1	106.00	0
1704-RA11103	SLIDER	SUPPLIER1	10.00	0
1704-RA11103	SLIDER	SUPPLIER1	1.00	0
1704-RA11103	SCAFFOLDING	SUPPLIER1	2.00	0

Figure 4-17: User interface showing the transaction history of particular supplier.

4.5.3 Advantages of the Material Information Management System

a) Systematic organization of the material information

The material information has been divided into a few sections to prevent confusion due to bulk of information. The primary sections consist of material transaction record, material inventory record, and suppliers' transaction history. In addition, the material transaction record has been subdivided into delivery and procurement sections due to the different properties of the information. Besides, the detailed information for all components of material transaction information have been categorized into material, warehouse, supplier, project and also system user, and all these components can be checked in separated sections.

Furthermore, all the transaction record inputted can be sorted in various patterns according to the preference of the users for better viewing purpose. For example, in the material inventory section, the users can arrange all the items by alphabetically sorting any information (material name, supplier name, inventory location, rating, and receive date) of the materials. All these features will ensure the material management works of a project is done in a systematic, organized and effective way.

b) Excellent information storage

All the information inputted into the system will be kept in the database unless it is deleted by the users. There is no worries of losing the information as long as the database is in good condition, unlike the conventional method of information storage where paperwork is required.

c) Convenient information retrieving process

All the information can be obtained easily with the searching feature provided. Other than the alphabetically sorting feature, users can directly enter the name or part of the name of the items they are interested in. This can ease the data searching process even for those records that are dated years ago. In addition, export function is also available for certain types of information where the users can print out the information. The function will be activated once there is any printing devices connected.

d) Security and privacy setting

All the information are encrypted and protected where only registered users can access to it. While for the registration, it can only be done through the account of authorized users. Also, the registration only valid after it is approved by the admin. Same procedure goes to the editing or deleting of material detailed information. This will ensure the information will not be simply edited by other users without the permission and alert of the admin.

e) Real time information update and access

The web based properties of the system allow all the users to access to the material information at anytime, anywhere. All the users can access to the system as long as they have a device that is connected to internet. By simply open the link with any browser, the system can be assessed. This feature allows users to get the real-time updates of any information uploaded to the system. Also, they can perform the material

transaction record without the restriction of time and place. In addition, the timeliness and adaptability of real-time data also helps the industry quickly adjust to new conditions. With the addition of real-time data, users can use the time previously spent collecting and analyzing data to create better strategy, re-design outdated approaches and increase overall performance.

4.5.4 Disadvantages of the Material Information Management System

a) Suppliers are not involved in the system

Due to the constraint of time and programming skill, the involvement of suppliers in the system is yet to be done, causing the system fails to integrate all the material management process in one system. The tender process can be done using the system if the suppliers are involved in it. Contractors can announce the tender process through the system and suppliers can tender for the procurement directly using the system as well. Also, the system can be a communication media for the contractors and suppliers as well with the involvement of suppliers. However, at this stage, only the basic information will be recorded in the system that eases the contractors in evaluating them.

b) The calculation of order point, ordering and carrying cost is not provided

The system is not capable to automatically calculate the order point, ordering and carrying cost for the users. This feature can help the users to determine the optimal order quantity that gives the minimum total cost spent on carrying and ordering cost. Moreover, the order point will tell the critical stock level left in inventory. This is important so that contractors know when to make an order to ensure the material will

arrive on time to replenish the stock. Currently, users are required to calculate the order point by themselves. Only after getting the value, users can input the value into the system during procurement process. The system will notify the users when the stock level reaches the value.

- c) The system does not provide a specific section for record of any privilege offered by the suppliers

In the section of suppliers' information, there is no any specific sub section designed to record any privilege such as discount of price, privilege payment method etc. offered by the suppliers. The similar feature available at this stage is just a slot to record any remarks on the suppliers. It takes more time for the users to evaluate the suppliers based on the privilege given as they have to read through the remarks words by words.

4.5.5 Future Development

a) Involvement of supplier in the system

One of the proposed development for this system is to involve the supplier in the system. When the contractors intend to make any procurement, they can announce the news through the system. As the registered users of the system, the suppliers will be notified about the announcement, and thus can decide to take part in the tendering process. When there are more than one suppliers participate in the tender, the system will sort out all the participants with their respective price, transaction record and detail information. The contractors can thus evaluate the tenderers more efficiently and select the best supplier for the procurement in shorter time with the aid of the system. Users can then proceed to contact the suppliers for negotiation and contracting for the transaction. Real time communication function is also one of the future planning for the system, to enable users to interact with suppliers before meeting each other in real life. Contractors can verbally negotiate and interview the suppliers first before proceeding to the detail contracting procedure.

b) Feature of calculating the economic order quantity

Throughout the market requirement survey, one of the high-rated expected feature of the material management system is being able to determine the optimum ordering and carrying cost of a material transaction. Therefore, the system will be able to calculate the optimum quantity to be ordered by equalizing the ordering cost and carrying cost as this will give the minimum total cost (summation of ordering cost and carrying cost). No any additional software or manual calculation is required for this feature, increasing the efficiency and productivity of the users in analyzing procurement needs.

c) Request for material procurement

With the involvement of supplier in the system, the entire procurement process can be conducted by using the system. When the construction site requires any material procurement, the person in charge will have to request for procurement by filling up the application through the system. Then the request will be evaluated by the admin (procurement department) before permission is given. Once the request is approved, the person in charge can announce the procurement in the system, which allows the suppliers to tender for it. Evaluation and comparison can be done among the tenderers, and further negotiation can be discussed with the shortlisted vendor/supplier. The exchange of documents (purchasing order, receiving order, contracts etc.) can be done through the system. The system will record the transaction once the material has been received. The contractors can rate the service and product of the suppliers in the system, and give feedbacks to the suppliers optionally.

d) An integrated system for information management

The ultimate goal of development for this system is to integrate all types of information required in the construction jobsite into a system. These information include request for information, material management information, equipment information, cost management information, site, schedule and construction information, quality control and quality assurance management information and safety information. All these types of information will function together as a system, where each types of information can be used for other types of information internally, without needing to export any information.

When individual systems are not integrated, users have to learn how to operate each

system separately. This extra workload will require more people, time and money to be invested on the implementation of information technology (IT) in construction project, and as proven by many researches, this is one of the major factor that stops the industrial players from investing in the implementation of IT in their companies.

With this integrated system, users can manage all the construction information easily by only using one system. This can efficiently reduce the financial expenditure spent on implementation of information technology in their company, as they only have to invest on one integrated system for all types of information, instead of one system for each types of information. The cost of maintenance and licensing will also be reduced due to this reason. In addition, the integrated solution allows faster statements to current numbers and developments. For example, all the preparation activities necessary to compare data between systems (for example when using different material numbers) can be omitted. It is also no longer necessary to elaborately “glue together” an analysis through various applications. Critical processes can therefore be identified far earlier and necessary remediation can be taken.

Besides, a situation can have changed during the transfer from one system to the other without the user noticing. Therefore, working in a uniform solution with real time data can greatly minimize this risk. Lastly, as the users work in only one system, accessing several isolated systems is unnecessary to get a current overview and/or to carry out activities. Therefore, the risk of “working parallel” where no department knows what the other is doing will be significantly reduced. Also, the data is much more transparent and their plausibility can more easily be corroborated.

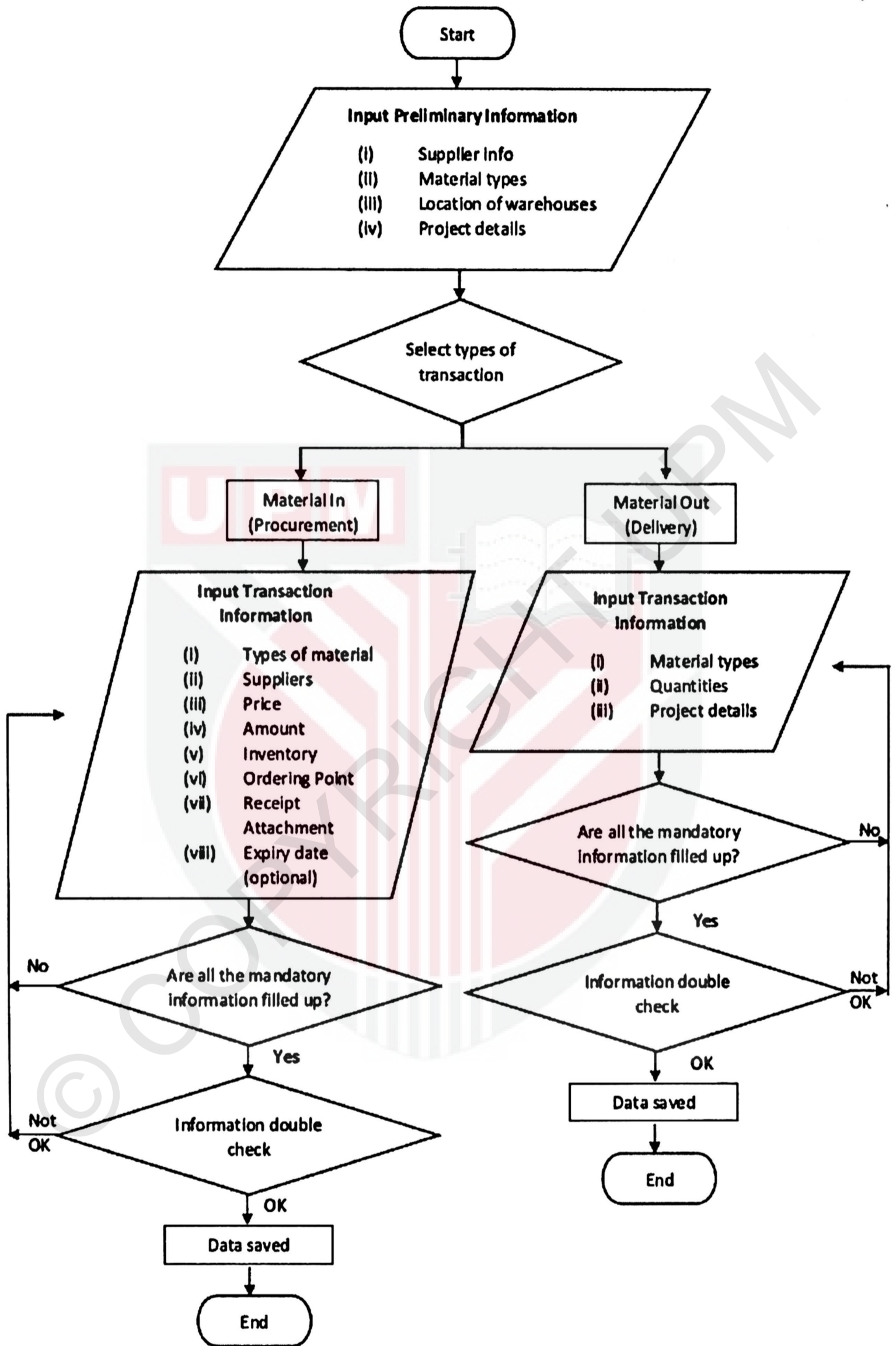


Figure 4-18: Process flowchart of the system for procurement and delivery.

4.6 Summary

After considering all the variables and feedbacks from the respondents as discussed in previous section, a web-based material information management system had been proposed as a solution to the inefficient material information management in the industry. The major functions of the system are as listed below:

- i. To record material transaction information (procurement and delivery),
- ii. To rate the quality of the material purchased,
- iii. To trace the material transaction history,
- iv. To trace the transaction history with particular suppliers

The advantages provided by the web-based system as compare to the ICT tools currently used in the industry are such as it gives a systematic organization of the material information, excellent information storage, convenient information retrieving process, advanced security and privacy setting, and real-time information update and access to the users. In contrast, the disadvantages of the system for current version are not involving suppliers in the system, not providing the auto calculation of ordering point, ordering and carrying cost, and not providing any specific section to record any privilege offered by the suppliers. The system had been demonstrated and tried by the respondents after that for validation purpose. Comments were gathered through the validation process and had been summarized as the future development for the web-based system. Some of the important features proposed for future development are such as the involvement of supplier in the system, auto-calculation of the economic order quantity and requesting function for material procurement process. Last but not least, the ultimate goal of developing the system is to upgrade it into an integrated system that can be used to manage all types of essential information for construction project.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.0 Conclusions

A research has been conducted to investigate the effectiveness of information management among the Grade 5 building contractors in Selangor, Malaysia through a structured questionnaire survey. The study is aimed to determine the types of information that are not well-managed in the industry. The response from the industry shows that the material information is the worst managed types of information at construction jobsite, and thus questions are set to deep dive into the material information management issue. The survey is trying to figure out the current practice of the material information management in the construction industry, the level of ICT implementation, the preference of using ICT in the construction project.

Questionnaires have been mailed to 100 randomly selected Group 5 building contractors in Selangor, Malaysia, and 38 responses (38%) are obtained within a month. The feedbacks have been compiled, checked for reliability, and analyzed using SPSS software in order to obtain the required information. The distribution of median value for effectiveness of management of all the jobsite information have been determined and tabulated in table 4-8. The effectiveness too has been ranked using the mean value as shown in table 4-10. The extreme items have been discussed where possible reasons

have been provided and supported by literature review. In addition, the adoption of ICT in different types of material information has been investigated as it is the worst-managed information at jobsite. The result is depicted in figure 4-4 and the types of software used is described in table 4-12 and figure 4-5. The effectiveness of material management of those who use and don't use ICT are compared and shown in table 4-14. The result of this analysis shows that ICT implementation could be a solution for poor material information management in construction industry and therefore, the advantages and disadvantages of software in use have been determined as shown in table 4-16 and 4-17 respectively. In order to enhance the marketability of the proposed ICT system, the respondents are asked on the expected features of the system and the feedbacks are shown in table 4-19. To ensure that the industry players are interested in the ICT implementation, question is asked on the preference types of material information that they would like to manage using ICT system. The result is depicted in table 4-18 and figure 4-7.

Last but not least, as an attempt to address the material information management issue, a web-based material management system has been designed and developed by referring to the feedbacks from the questionnaire survey. The functions and features, advantages and disadvantages of the system have been discussed in Chapter 4.

The following are the conclusions that answer the objectives set for this research.

Objective 1: The types of information required at construction jobsite had been determined to be Request for Information, Material Management information, Equipment Management information, Cost Management information, Schedule and Means and Methods information, Jobsite Record information, Submittals information, Safety information and Quality Control / Quality Assurance information.

Objective 2: The type of information that are the worst-managed among the targeted population is the Material Information, followed by Quality Assurance / Quality Control information and Schedule and Means and Methods information.

Objective 3: The selected type of information to be tackled for this research is Material information. A web-based material information management system has been proposed as the remediation for this issue. The main functions of the system are to record and request material transaction and to keep the transaction records with all the suppliers. The main advantages of the system are such as it provides systematic organization of the material information, real-time material information updates and access and convenient information retrieving procedure.

5.1 Recommendations

Generally, in order to improve the effectiveness of information management in construction project, one of the high potential solution is by adopting Information Communication Technology (ICT) such as computer based system, web-based management system and radio-frequency identification (RFID) in the operation of construction projects. It has been proven that implementation of ICT gives better work quality, increased efficiency, better financial control, better communication, faster and simpler access to public data, greater flexibility to satisfy customers, the possibility of sharing information in general, easier to use a lot of data and the convenience of telecommuting. In addition, the use of an integrated information management system too is recommended to improve the effectiveness of information management. The one-system-for-all-information idea can not only reduce the financial investment on ICT implementation, but also might increase the efficiency of information management and provide real time data without the need of accessing various system. To conclude, the small, medium contractor companies are suggested to get rid of the traditional methods of managing information that are mostly paper-based, and invest more resources on the implementation of ICT in their projects due to all the benefits listed in this research. More time and fund should be invested on preparing the equipment required and technical staff training. Even though the direct profit to the contractors might not be obvious, the long-term benefits are undeniable where the overall productivity and efficiency will increase and thus they will be much more competitive in the industry.

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APPENDICES A



**FACULTY OF ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING**

QUESTIONNAIRE

Research on The Information Management Applied in Construction Industry In Malaysia.

Purpose of research:

The main purpose of this research is to identify the types of information that are not being well managed in construction project. The findings of this research are aimed to improve the information management of building construction project for Small, Medium Building Contractors companies.

I will appreciate it if you could complete the enclosed questionnaire. **Kindly return the questionnaire with the envelope provided.**

Thank you.

(All information given will be kept private and confidential.)

Prepared by,

OOI WEI KIAT

174419

BACHELOR OF CIVIL ENGINEERING

Section A: Respondents Background

Instruction: Please fill in the information in the spaces provided or tick (/) the appropriate brackets.

1. Respondent's Name (Optional) : _____

2. Respondent's Post : Project Manager / Deputy Project Manager ()
Civil Engineer / Project Engineer / Site Engineer ()
Quantity Surveyor ()

3. Year of experience in construction field:
0-5 Years ()
5-10 Years ()
10-15 Years ()
15 and above ()

4. Company's Name : _____

5. Telephone Number : _____

6. E-Mail Address : _____

* All the information given will be kept private and confidential.

Section B – Types of Information that are not well managed

During the construction phase of a building project, huge amount of information flows occurs every day. However, it was found that some of the information are not being well managed which will then affect the construction progress. Among the types of information listed below, please rate (v) the effectiveness of the management applied to the types of information for your project.

Types of Information	Effectiveness of Information Management Being Applied for The Information listed				
	Bad	Poor	Moderate	Good	Excellent
1. Request for Information – All information exchanged regarding pre-project, correspondence, design, and construction startup.					
(a) Consultation with engineers / designers for questions regarding design and intent.					
(b) Sub-contractor information					
(c) Contract specification – Access to specifications or information regarding specifications.					
(d) Contract drawings – Access to contract or shop drawings.					
(e) Work package information (Eg. Scope of work, materials and equipment required etc.)					
(f) Means and methods (Verification of the planned means and methods of construction by the site staffs.)					
(g) Implementation problems (Consultation when site staffs discover that an item cannot be installed according to the owner’s plans or contractor’s methods.					

* All the information given will be kept private and confidential.

Types of Information	Effectiveness of Information Management Being Applied for The Information listed				
	Bad	Poor	Moderate	Good	Excellent
2. Material Management – Information of all material required in a construction project					
(a) Access to material management					
(b) Material Location					
(c) Material order status					
(d) Request materials to site					
(e) Place material orders					
3. Equipment Management – All information exchanged with regards to the equipment required on site.					
(a) Equipment Location					
(b) Fuel Monitoring (all the information regarding to fuel for those equipment)					
4. Cost Management (Information related to cost and accounting of a project)					
(a) Budget					
(b) Material cost accounting					
(c) Equipment cost accounting					
5. Schedule and means and methods					
(a) Schedule updates					
(b) Delay recording					
(c) As-built records – Records of all the elements/work built at site.					
(d) Productivity information					

* All the information given will be kept private and confidential.

Types of Information	Effectiveness of Information Management Being Applied for The Information listed				
	Bad	Poor	Moderate	Good	Excellent
6. Jobsite record keeping					
(a) Recording timesheets					
(b) Progress reporting					
(c) Exception reporting – Information related to the mistakes, goofs, or mishaps of the project)					
(d) Visitors' log					

7. Submittals					
(a) Test results					
(b) Revisions to submittals (Correction to an original submittal when the specification is not met)					

8. Safety					
(a) Accident reporting					
(b) Reporting injury (violations)					

9. Quality control / Quality Assurance (QC/QA)					
(a) Initiate inspections					
(b) Report QC/QA problems					
(c) Report inspections results					

* All the information given will be kept private and confidential.

Section C – Information for material management.

****Answer this section only if you think that information for material management is an issue for your company.**

Instruction: Please (v) in the brackets for the answers.

1. Did your company used any software or IT tools to manage the information listed below?

(Proceed to Question 6 if there is no software implemented in your company)

- a. Access to material management Yes () No ()
- b. Material location Yes () No ()
- c. Material order status Yes () No ()
- d. Request materials to site Yes () No ()
- e. Place material orders Yes () No ()

2. What kind of software is used to manage material information in your company?

- a. Microsoft Excel ()
- b. COBRA ()
- c. PENTA TECHNOLOGIES ()
- d. Others () Please specify: _____

3. How effective is the software stated above in managing the information?

- a. Very Low ()
- b. Low ()
- c. Moderate ()
- d. High ()
- e. Very High ()

4. What are the advantages of the software?

- a. It organizes the information and eases information retrieving ()
- b. It keeps good records of the information ()
- c. Easy to use ()
- d. Low cost ()
- e. Others, Please specify: _____

*** All the information given will be kept private and confidential.**

5. What are the disadvantages of the software?
- a. The initial upfront expenditure is too costly ()
 - b. Require too much dependency of specialists ()
 - c. Require excessive work to implement ()
 - d. The software is too complicated to use ()
 - e. Do not required by customers ()
 - f. Others, Please specify: _____

6. Do you prefer to use any IT tools or software in managing those information?

- | | | |
|----------------------------------|---------|--------|
| a. Access to material management | Yes () | No () |
| b. Material location | Yes () | No () |
| c. Material order status | Yes () | No () |
| d. Request materials to site | Yes () | No () |
| e. Place material orders | Yes () | No () |

7. In your opinion, which of the following features are useful for managing material information?

- a. Record the quantity of the material left ()
- b. Record the location of the material ()
- c. Record the price of the material ()
- d. Record the supplier or vendors ()
- e. Comparison of the vendors or suppliers base on the records ()
- f. Record the specification of the materials ()
- g. Indicate the storage space available ()
- h. Record the expiry date of the material ()
- i. Help in determining the optimum ordering and carrying cost ()

8. Would you like to share your experience of the project more detail in a walk-in interview after this questionnaire? Please fill in your name, contact number or email if yes. Tick in the bracket provided if the information is same as Section A.

Name : _____

Contact no. : _____

Email : _____

Same as filled in Section A ()

----- End of Questions, Thank you for your time -----