COMPARISON OF MATERIAL WASTAGE BETWEEN CONVENTIONAL AND CAST IN-SITU SYSTEM FORMWORK IN CONSTRUCTION INDUSTRY

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A project report submitted in partial fulfilment of the requirements for the award of the degree of Bachelor (Hons.) of Quantity Surveying

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August 2011

DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

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Specially dedicated to
my beloved grandparent, father and mother

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ABSTRACT

The construction by nature is not an environmental friendly activity. It creates serious environmental problems with deadly consequences such as air pollution, water pollution, landslides, flooding and many others. Moreover, the construction industry also reported generating unacceptable levels of material wastage. Building materials are any materials which used for construction purposes. It is an important input into the site production process which will affect the construction projects finish in the time specified with the required specification. Any attempt to quantify the materials in terms of costs would come to the realization that they contribute a significant proportion towards the total construction costs. The material wastage occurs at all stages of building process starting from the design stage until the handover of the projects and there are many factors contribute to the generation of material wastage no matter direct or indirect wastage. The factors which cause the material wastage in a project were identified in four major sources such as in design, procurement, material handling, and operational. Due to the building materials contribute a significant proportion towards the total construction costs and consist of various types of material in different quantity, thus the building materials must be controlled and the material wastage must be prevented. From the conclusion drawn from the types of material wastage, causes of construction waste, effectiveness of waste prevention methods and material wastage levels between conventional and cast in-situ system formwork construction, it is proved that the use of cast in-situ system formwork in construction industry will prevent the material wastage.

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N_5	number of respondent strongly agree
N_4	number of respondent agree
N_3	number of neutral respondent
N_2	number of respondent disagree
N_1	number of respondent strongly disagree
r	rank correlation
$\sum di^2$	sum of the squares of the differences
n	number of data points

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In the 9th Malaysia Plan, the construction sector was the only sector that recorded a positive growth during every quarter of 2009. So that, the construction sector have growth 5% in 2009, and subsequently 8.7% for the first quarter of 2010 as against the overall GDP growth of 10.1% during the first quarter of 2010. (Shaziman, 2009) It was within this scenario that the construction industry act as the momentum to economy, improve the standard of living and create job opportunity to the countries.

The construction industry in particular has been known among the main consumers of resources and energy. Nevertheless, the construction by nature is not a friendly activity to the environment. It creates serious environmental problems with deadly consequences such as air pollution, water pollution, landslides, flooding and many others. Moreover, the construction industry also reported generating unacceptable levels of construction wastage. A report published by the Institution of Civil Engineers (ICE 1996) stated that almost every year are generated over 500 million tonnes of construction waste. The unacceptable levels of construction wastage make the landfill space is becoming scarce and the cost of tipping materials is very high and rising. (Cooke & Williams, 2004)

Generally material wastage in the construction industry can be divided into on-site and off-site operational activities. On-site activities which mean the activities related to the construction works. It requires sufficient adjacent to the actual

construction area on which to carry out the work. While off-site activities are the activities out of the construction site including manufacturing and transportation of materials and components.

Interrelated to each other, both off-site and on-site activities also produce huge quantity of construction waste and cause serious environmental consequences to our environment. In some country they have adopted some strategies of wastage deposition to manage such a huge quantity of construction waste.

Conventional construction encompasses traditional forms of construction for structural load-bearing elements which fabricated on-site. It typically consists of reinforced concrete, brickwork and or structural steel. The conventional construction has the advantages of easy transportation of wet concrete. It is flexible in any shape of design and on-site adjustment can be arranged easily provided carpenter is available. The disadvantages of the conventional construction is it fabricated in an 'unprotected' environment, additional time is required for the curing process, and it requires more temporary works and space to store the construction materials such as timber, steel, cement and many others.

Cast in-situ system formwork is a system which consists of the table form and tunnel form construction method. These construction methods are technically to all type of building construction and it can increase productivity and quality of work through the use of better construction machinery, equipment, materials and extensive pre-project planning. The objective of cast in-situ system formwork method is to eliminate and reduce the traditional site-based trades like traditional timber formwork, brickwork, plastering and reduce labour content, in order to speedy construction, low maintenance, durable structure and low cost.

In Malaysia, even through cast in-situ system formwork construction is not new and have many published on the subject. Nevertheless, conventional construction seems the main choice of the contractors in the construction industry. At a time of financial difficulty when competition is fierce, any construction method which can get better savings that can be achieved must be the first choice of the clients and contractors.

1.2 Rationale of Study

Some degree of waste of material is inevitable in the construction process; all Quantity Surveyors will allow wastage when pricing a bill of quantities. Experience shows, however, unless the management of control material is very strict, material wastage can frequently exceed with a huge amount.

Generally in the conventional construction, the contractors will make sure all the construction activities are carry on fast and smoothly to prevent any delay of construction period and earning more profit in the project. Despite the contractors need to speed up the construction progress, but they cannot lack of attention to the material wastage on site. Whereas the cast in-situ system formwork, it has the advantages over the conventional construction that include speedy construction, low maintenance, reduce waste, high quality surface finishes can be achieved and so on.

Since the trend of adopt the cast in-situ system formwork in Malaysia has been growth, it is believed that this study will contribute to various project participants in the future. Besides that, this study will help to reduce material wastage in the construction industry and various methods of waste prevention will be discussed and it is suitable for them to refer and choose a suitable construction method to manage the material waste and achieve a desirable profit.

1.3 Aims and Objectives

The aim of this study is to investigate the construction wastage in construction industry. In order to achieve the aim of the study, there are three objectives established as follows:

i. To determine the types of material wastage;
ii. To identify the causes of construction waste;
iii. To establish the waste prevention methods in construction for conventional and cast in-situ system formwork.

1.4 Scope of Study

Scope of research will determined to facilitate the literature research, by focusing on certain field in literature research and data collection process. The research covers:

i. Research area involved in Kuala Lumpur and Selangor.
ii. Collect data on the materials wastage generated in construction building.
iii. Focus on materials waste between conventional and cast in-situ system formwork (Table formwork and Tunnel formwork).

1.5 Limitation

In generally, there are some of people are not familiar with usage of the table form and tunnel form system so that will consider this is a new technology in construction industry. Yet, they probably associate table form and tunnel form are only used for limited sector of construction project such as multi-storey building.

In addition, they also low of opinion about the problems encountered by the conventional building system. Due to the usage of table form and tunnel form system is uncommon for local construction industry compared to conventional construction, the result from the questionnaire may affect the actual scenario. It is because they lacked of awareness and knowledge in the table form and tunnel form system.

1.6 Research Methodology

The research methodology is an essential part for the researcher to know the ideal methodologies in order to meet the aim and objectives of this study. In this study, the researcher will collect information from reference books, and journal articles to introduce some theories regarding to material wastage between conventional and cast in-situ system formwork. Moreover, internet sources also a part of the research methodology for the researcher to get the latest updated information of construction waste issues.

In order for the researcher to get some practical information from the construction industry, the data collection can be collected by using survey questionnaire. To strengthen the finding of the survey and to assist in providing more information about building material wastage, the observation was also conducted in this research. The method and detail on this data collection, location, and analysis will be explained in more detail in chapter 3 and 4. The research methodology flowchart is shown in Figure 1.1.

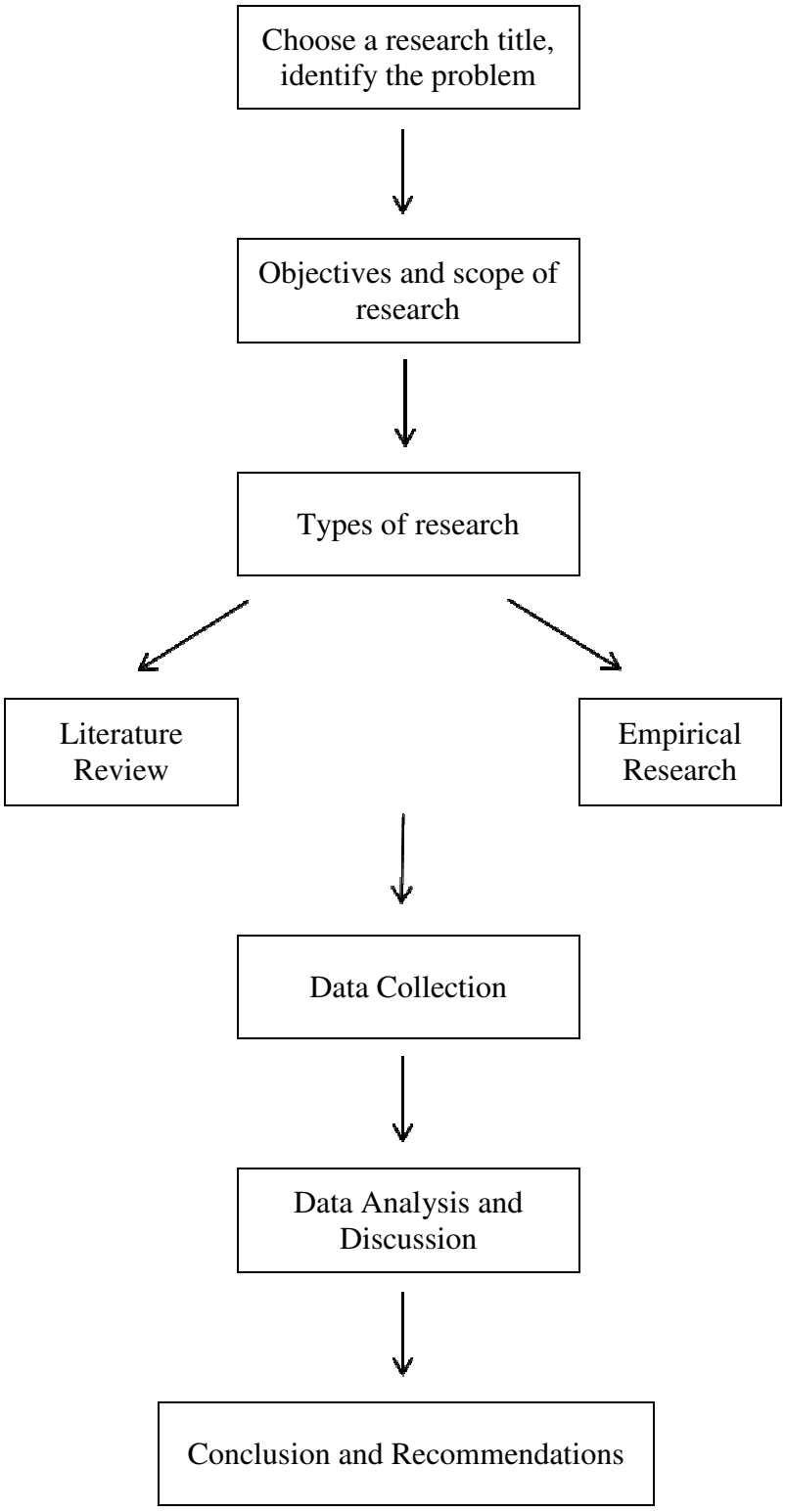


Figure 1.1: Flowchart of Research Methodology

1.7 Chapter Outline

Chapter 1

Introduce the area being investigated for this study. These are the background of the relevant material wastage level in construction industry, rationale of study, aims and objectives, scope of study, limitation and research methodology.

Chapter 2

Define the comparison between conventional and table form and tunnel form system in term of definition of waste, types of waste material, causes of construction waste, waste prevention methods in Malaysia and others country, materials wastage level between conventional and cast in-situ system formwork and conclusion.

Chapter 3

Explains the method of research for this study included the research strategy, method of data collection, the technique to analysis the collected data and conclusion.

Chapter 4

Discuss of the interpretation and analysis of the results obtained from the survey research and findings from the case study.

Chapter 5

States the conclusion and recommendation of the entire study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In generally, construction wastes are in the form of building debris, brick, concrete, steel, timber and mixed site clearance materials. These construction wastes arise from various construction activities, including land excavation and formation, civil and building construction, industrial construction, site clearance, demolition activities, and building renovation.

The construction wastes originate from various sources in the whole process of implementing a construction project. There are many factors contribute to the generation of material wastage no matter direct or indirect wastage. Any projects which do not have a workable and efficient material management will face the material wastage problems and that subsequently will affect the construction costs and may lower the profit margin.

Hence, waste prevention method is a most pressing issue nowadays. However, data is not readily available on the current structure of construction waste flows by the source of generation, type of waste, intermediate and final disposal and the amount of waste reduced at source, reused or recycled on-site or off-site.

2.2 Definition of Waste

Under the United Kingdom's Environmental Protection Act 1990 (EPA 90) Section 75 stated that waste includes any substance which constitutes a scrap material, an effluent or other unwanted surplus arising from the application of any process or any substance or article which requires to be disposed of which has been broken, worn out, contaminated or otherwise spoiled. It means that the construction waste consists of unwanted material produced directly or incidentally by the construction industry.

The wastage of construction materials can be classified into two types, which are direct and indirect material waste. Skoyles and Skoyles (1987) defined direct waste is a complete loss of those materials, which were damaged and could not be repaired and subsequently used, or lost during the building process. By contrast, indirect waste normally occurs when the materials were not lost physically and it represented only a monetary loss.

In the other term, the definition of waste in Lean Production paradigm described it as a concepts related to process and operation. Process refers to the flow of activity form one worker to another worker; whereas operation is an activity taken by worker such as the worker transforms the raw material to finished product or walking to another location to get parts (Shingo, 1988).

Womack and Jones (1996) described waste are related to the human and industry activities which absorbs the time, resources or place but works with no value to the product, such as the process steps that are not needed, production of items that completed but not comply with the instruction, workers waiting for instruction and so on. This represented waste is directly linked to the human development and industrial development, both technologically and socially.

2.3 Types of Waste Material

In Malaysia, generation of construction waste covers almost every construction stage. The sources of construction waste generation have to investigate in four major components of construction waste such as wood, concrete, metal, brick and others such as waste generated from finishing works, such as packaging of materials, ceramic tiles, and insulation. The common sources of construction waste generation identified were shown in Table 2.1. (Lau, Whyte, & Law, 2008)

Table 2.1: Common Sources of Construction Waste Generation

Waste Type	Descriptions	Sources
Wood	Dimensional lumber	Formwork, roof truss
	Plywood	Formwork
	Timber props	False work
	Sawn timber	Formwork, roof truss
Concrete	Substructure	Footings, piling
	Superstructure	Beams, columns, floor slabs
	Drains and gutters	Drainage works
Metal	Reinforcement bar	Reinforcement fixing
	Wire mesh	Reinforcement fixing
	Roofing sheet	Roof
	Aluminium frames	Window, false ceiling
Brick	Clay brick	Wall, fencing works, gutters
	Cement brick	Wall, fencing works, partition walling
	Cinder block	Wall, fencing works
Others	Packaging	Cement packaging, plastics, cardboard, timber pallets
	Gypsum & cement board	False ceiling
	Plaster	False ceiling, finishing works
	Ceramic	Roofing tiles, floor tiles, wall tiles
	PVC Pipe	Plumbing works
	Conduit & wiring	Electrical works

A study was conducted by Lau, Whyte, and Law (2008) to investigation the composition and characteristics of residential construction waste in the City of Miri, Sarawak. Through field observation and site monitoring for one of the study sites were identified that the residential construction waste as shown in Figure 2.1: Wood is 64.0%, Concrete is 20.7%, Brick is 9.1%, Metal is 2.5% and Others is 3.7%.

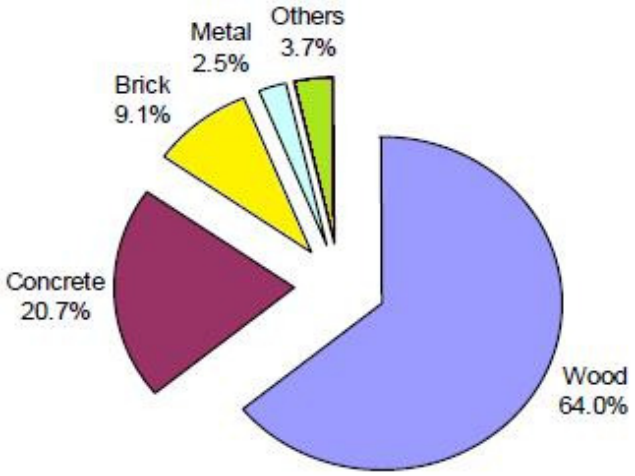


Figure 2.1: Sample Composition of Residential Construction Waste

2.3.1 Timber

Timber as describes wood which has been cut for use as structural material for construction. The majority used of timber in construction sites are in formworks during casting the structural elements. According to Waste Online (2006), timber waste form construction is produced in large amount all over the world. In the UK, it is estimated that each year up to 750,000 tonnes of timber waste is produced by construction and demolition.

Timber possesses many advantages that make it a popular building material. It is relatively inexpensive, high load capacity and lightweight material that is easy to cut, shape and join by relatively cheap and simple hand or power operated tools in the production of structural elements or formworks. The timber can be cut and shaped to producing any unique and complex forms of concrete structures. However, the timber has the disadvantages of low durability and reusability cause the timber one of the high wastage material.

2.3.2 Metal

Metals are the waste generated from ferrous and non-ferrous materials, such as reinforcement bars, pipes, steel, aluminium, copper, brass and others. The reinforcement bars is very important used in reinforced concrete and reinforced masonry structures in the construction to giving ridges for better frictional adhesion to the concrete. Concrete are strong in compression but weak in tension and contrary the steel are strong in tension and weak in compression.

Metal was among the lowest waste generated from the others components of construction waste. This is mainly due to the relatively high cost and high recycles value in the local market. Off cuts of reinforcement were usually collected and placed properly for recycle or future use. However, the operative's ability to measure the lengths of steel to obtain the most economical cuts is very important and condition of steel while storing must take into account to prevent serious rusting because steel is relatively expensive compared to other materials and the wastage of steel material will cause a significant impact on the project cost.

2.3.3 Concrete

Concrete is a building material composed of cement as well as other cementitious material such as course aggregate, fine aggregate, water and chemical admixtures. Concreting works is a major building process for substructure and superstructure, and most of the works are made from ready-mixed concrete. However, the concrete also one of the high wastage material caused by loss attributed to excessive material ordering, overtime of concrete, broken formwork and redoing due to poor concrete placement quality.

2.3.4 Brick

Brick is a building material made from clay, calcium silicate, and concrete. The standard size of brick is 215mm x 102.5mm x 65mm and there are so many types of brick masonry such as common brick, facing brick, and engineering brick. Masonry works is the building process to enclose and protects a building or serves to divide buildings into compartments or rooms. Brick masonry units may be solid, hollow, or architectural terra cotta. All types can serve a structural function, a decoration function, or a combination of both.

Brick refers to waste resulting from clay brick, cement brick and cinder block and others. However, the brick had always been one of main components of construction waste. The causes of brick waste generally will be carelessness of off-loading and handling, poor bricklaying workmanship such as cut bricks, incremental ordering problems on small jobs and so on. Due to the bricks are fragile characteristic of the material, it caused that large amounts of bricks are broken and have to be dumped in landfills or used as a backfill material.

2.3.5 Others

Furthermore, packaging waste is also one of the high wastage materials generate from construction sites such as cement packaging, plastics, cardboard and timber pallets. Much of this waste is unnecessary and significant amounts could be reused, recycled or completely avoided, rather than sent to landfill.

In the case of ceramic tiles, waste is mainly caused by sawing that becomes necessary when insufficient attention is paid to the dimensions of the available tiles and breakage during transport and so on. Besides the wastes of packaging of materials and ceramic tiles, other raisings usually refer to waste generated from finishing works such as insulation, PVC pipe, light fixtures, nails, electrical conduit and wiring, paints and others.

2.4 Causes of Construction Waste

In generally, waste will occurs on site for a number of reasons, it resulting from all stages of building process starting from the design stage until the handover of the projects. There are many factors contribute to the generation of material wastage no matter direct or indirect wastage. The factors which cause the material wastage in a project were identified in four major sources as shown in Table 2.2: (1) design, (2) procurement, (3) material handling, and (4) operational. (Ekanayake & Ofori, 2000)

Table 2.2: Sources and Causes of Construction Waste

Design	Procurement	Material handling	Operational
* Lack of attention paid to dimensional coordination of products * Changes made to the design while construction is in progress * Designer's inexperience in method and sequence of construction * Lack of attention paid to standard sizes available on the market * Designer's unfamiliarity with alternative products * Complexity of detailing in the drawings * Lack of information in the drawings * Errors in contract documents * Incomplete contract documents at commencement of project * Selection of low quality products	*Ordering errors (eg., ordering significantly more or less) *Lack of possibilities to order small quantities *Purchased products that do not comply with specification	*Damages during transportation *Inappropriate storage leading to damage or deterioration *Materials supplied in loose form *Use of whatever material which are close to working place *Unfriendly attitudes of project team and laborers *Theft	*Errors by tradespersons or laborers *Accidents due to negligence *Damage to work done caused by subsequent trades *Use of incorrect material, thus requiring replacement *Required quantity unclear due to improper planning *Delays in passing of information to the contractor on types and sizes of products to be used *Equipment malfunctioning *Inclement weather

2.4.1 Design

During the design stage of a construction project, the material wastage can be subjected to occur in the future. The most often causes occur during the design stage are the designers pay less attention to the dimensional coordination of products and the standard sizes available in the market. It may resulted the standard sizes available in the market cannot fit with the designed sizes and the workers have to cut the materials to suit the designed sizes. Following causes happened in the construction project is the changes of the design made by the client and the designer while

construction. These may caused the previous works done has to be aborted and also resulted huge of material wastage in that project.

Moreover, the complexity of detailing in the drawings and specification are usually make the project participates confused and improper planning. Due to the complicated of the assembly process stated in the specification and the lack of knowledge and experience by the workers may lead to the material wastage in the construction project.

2.4.2 Procurement

The material wastage of a construction project during procurement is involved to both of materials suppliers and the contractor or subcontractor. During the procurement stage the most often causes are incorrect taking-off and scheduling of materials, material ordering errors, supplier's error and others. According to Illingworth (2000), such situations generally start with incorrect taking-off of materials. If material over measure, where the quantities have been ordering is delivered, it will cause huge of material waste. If under ordering, waste can be created by delay to the contract. This shows that incorrect requisitioning and ordering of materials will lead to the material wastage in construction industry.

Incorrect requisition and ordering of materials also will lead to the material wastage. According to Forster (1989), if the requisition and ordering of materials are made prematurely by the purchasing department to enable the most competitive prices or the suppliers tend to deliver the materials to the site earlier, those materials which delivered to site too earlier before they are required will lead to loss / and damage. For example, if the marble tiles delivered to site before the finishing works start, it may cause a serious loss/ and damage and direct result an unnecessary wastage to the materials.

2.4.3 Material Handling

During the handling of the materials, the material wastage can be subjected to occur due to the unfriendly attitudes of the project team and labourers. The building material were damage or broken during transport because of poor packing or insufficient protection during loading. Especially for the fragile materials such as roof tiles, floor and wall tiles, glass, it may easily be damage or broken, if exposed to dropping or bumping during transportation.

Moreover, inappropriate storage material by the site personnel also will leads to damage or deterioration of the materials. According to Forster (198), if the care of selection of suitable storage points was not exercised, the material wastage can increase substantially. So that, pre-planning to the space required for storage of materials is essential, it may consideration on the various delivered materials is to be placed for safe keeping and avoiding loss, vandalism and thief.

2.4.4 Operational

The material wastage of a construction project during operation is related to the errors made by tradespersons or labourers; accidents due to negligence; damage to work done caused by subsequent trades; use of incorrect material, thus requiring replacement; equipment malfunctioning and so on. The errors made by tradespersons or labourers such as fails to comply with the contract drawings or fails to comply with instruction given will cause the material wastage in the construction project. If the contractor fails to comply with the contract drawings, it will cause the contractor to redo the works.

The malfunction of equipment also will cause the material wastage in the construction projects. If the mobile crane or the pocket vibrators malfunction while concreting the upper floor slab, these will cause the delay time of concrete and forced to dispose the concrete.

2.5 Waste Prevention Methods

In fact, unacceptable levels of material wastage in construction projects will creates serious environmental problems with deadly consequences and increase the project cost meanwhile lowering the contractor' s profit margin. Due to the building materials contribute a significant proportion towards the total construction costs and consist of various type of material in different quantity, thus the building materials must be controlled and the material wastage must be prevented. In order to reduce the material wastage in construction projects, certain waste prevention methods need to be adopted at all stage of building process starting from the inception stage until the handover of the projects.

2.5.1 Good Attitudes of Project Participants

Hussey and Skoyles (2004) stated that a change in the attitudes of project participants including clients, designers, contractors and construction workers towards the practice of sustainable construction waste management may be more efficient than changes in construction technology. The clients may take the lead to wish the construction waste can be minimised during the construction period. Following by the changes of designer's attitude to reduce the construction waste in a construction project including reduce the changes of design while construction is in progress; reduce the complexity of detailing in the drawings and specification; and pay more attention to the dimensional coordination of new products and the standard sizes available in the market.

The changes of contractors and his workers' attitude in reducing the construction waste are important because they occupy a critical position in the construction waste generation chain and their attitudes have a direct and immediate impact upon the efficiency of construction waste management.

2.5.2 Material Procurement and Handling

An improvement in material procurement system may help to reduce the construction waste in a construction project. To reduce the ordering error, sufficient information is vital to mitigate the effect of those delays to the entire project progress. In order, communication between the each party for responsible to the material procurement are necessary, such as quality control personnel in charge of the areas of specifications, contracts, scheduling, purchasing and stock control. Often there is no established pattern for issuing information on the progress of delivery of materials. Thus panic situation are often occur at every delay resulting from late arrivals. To reduce these problems, Hira (1984) had suggested that in a large company it is need to provide a purchase functions are carried by a team of material procurement personnel whose duties are as outlined in Figure 2.2.

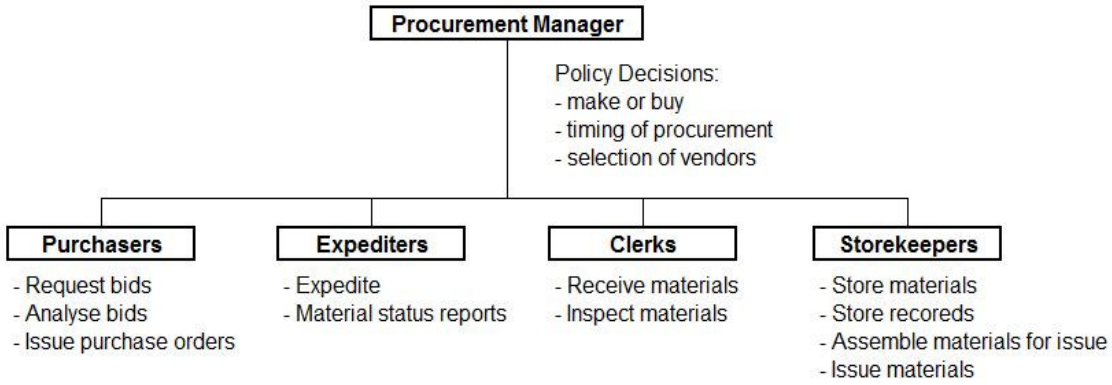


Figure 2.2: Duties of a Team of Material Procurement Personnel

2.5.3 Material Storage Management (MSM)

Nowadays, Material Storage Management (MSM) is in great concern in many countries. It is no longer a new and hot issue in Malaysia construction trend, but still have most of local construction company are not using this kind of management system. Some of the construction company still not fully appreciate that material waste means financial loss and will direct increase the production price.

In fact, effective Material Storage Management (MSM) is essential to suit the current trend. The concept of Material Storage Management includes the planning, inventory control, purchasing, receiving and stores, material handling and physical distribution. It effective for company to reduce wastage, maximise profits, establish needed controls and reduce costs. (Ping et al., 2009)

2.5.4 Design to Minimize Material Wastage

During the design stage of a construction project, detailed in the drawings and specifications, and dimensional coordination of products and the sizes available in the market should be taken into account by the designer to avoid significant amount of waste. Generally, the design of a building is closely oriented to the building process. The more complex of design in a building, the more complicated detailing in the drawings and specifications, thus the more significant in construction waste.

Although changes of design while construction maybe required, the design should be flexible enough to accommodate changes without causing any material wastage. In the US, some of the company have adopted Design for Environment (DFE) to minimize the environment impact such as waste in the construction process, in order without sacrificing function and quality. Design for Environment (DFE) will identify the concept, scheme and detail design among will cause the waste and adopt a waste reduction approach to solve each causes of the wastage in construction industry. (Keys, Baldwin, & Austin, 2011)

2.5.5 Recycling Material

Recycling involves processing used materials or waste into new products or usable raw material in order to prevent the waste of potentially useful materials, reduce the demand on finite natural resources, save energy in production and transportation, and reduces the risks of pollution. Some materials are often of better quality and purity and have a better potential for recycling.

United States Environmental Protection Agency [US EPA] (1998) found that the recycling rate for steel from construction and demolition (C&D) is about 85% (18.2 out of 21.4 million tons generated). These figures include not only scrap steel form building but also from roads and bridges. Due to the recycling rates of metal among the materials recovered from C&D sites are highest, so it has the good market in existence especially for ferrous metals such as copper and brass.

A specification can be amended in construction industry to regulate the use of recycled materials as hardcore in foundations, sub-base in road pavement and concrete in less technically demanding works. There are many different materials can be recycled with a different technique. For example, concrete aggregate collected form demolition sites are put through a crushing machine, often along with bricks, dirt and rocks. Smaller pieces of concrete are used as gravel for new construction projects. Crushed recycled concrete can also be used as dry aggregate for brand new concrete if it is free of contaminants.

Moreover, most of the packaging that construction work generates not only can dump in landfill, it also can be sending to recycled. Even some of the packaging will contain hazardous substances and it may require special handling, but the packaging still can be successfully recycled. Although most of materials can be recycled, but the effective recycling is that often only can produced low levels of materials. But in fact, the construction waste recycling, not only has enormous economic benefits for construction field, will also produce tremendous benefits for environment.

2.5.6 Use of Cast In-situ System Formwork Method

Cast in-situ system formwork construction is technically to all type of building construction and it can increase productivity and quality of work through the use of better construction machinery, equipment, materials and extensive pre-project planning. The objective of the cast in-situ system formwork is to eliminate and reduce materials and labours content in construction process, so it is considered as an effective and efficient method for waste minimization.

2.5.7 Just in Time (JIT) System

According to Griffith and Watson (2006), Just in Time (JIT) philosophy has been used in the manufacturing for a number of years. JIT is an approach to manufacturing which can improve a company's performance. The concept is based on making the process more customers orientated, simple and co-ordinated.

Just in Time (JIT) system is focused on improving the productivity of the industry and eliminate the waste of non-value-adding activities which impacting by materials and plants. It provide the most efficient and effective way for a company by eliminating any waste, in order to ensure the product is produce at a lower cost, faster and at a high quality level, while using a minimum amount of resources.

2.6 Comparison Material Wastage Between Conventional and Table Form and Tunnel Form Construction

Robert et al. (2006) stated that usage of cast in-situ system formwork greatly reduces conventional formworks and falseworks in the construction process. Compared to conventional construction, cast in-situ system formwork generally has the benefit in achieving cost savings through considerable savings in erection and dismantling time.

The cast in-situ system formwork as well as table form and tunnel form have the advantage for reuse of formwork in numerous times example for tunnel form, it can usually be reused for 500 to 1,000 times. Additionally, table form and tunnel form using appropriate quality control to achieve a smooth, high quality concrete surface finish and dimensional accuracy eliminates finishing works like plastering. Since these system can reduces the required finishing works, thus providing another cost savings and speeding up the entire construction process.

2.7 Conclusion

As a conclusion, construction waste can be classified into two types, which are direct waste and indirect waste. Direct waste is a complete loss of materials which is damage or theft from site. Whereas indirect waste is a monetary loss and the materials were not physically.

The materials waste occurs at all stages of building process starting from the design stage until the handover of the projects. There are many factors contribute to the generation of material wastage no matter direct or indirect wastage. The factors which cause the material wastage in a project were identified in four major sources such as in design, procurement, material handling and operation stage.

Each type of waste prevention methods has their own effectiveness of waste reduction for applicable in construction industry. Hence, certain waste prevention methods need to be adopted at all stages of building process starting from the design stage until the handover of the projects to reduce the material wastage in construction projects.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

The research methodology is an essential part for the researcher to know the ideal methodologies in order to meet the aim and objectives of the study. Malaysia Nuclear Agency [MNA] (2007) stated that the term *research* is often described an entire collection of information about a particular subject, and is usually related to a problem that needs to be solved. An organised and suitable research methodology will ensure the effectiveness and smoothness of the research process.

There are certain research methodologies and procedures are used by the researcher to identify the causes of construction waste and the waste prevention methods, and to differentiate the material wastage levels between conventional and cast in-situ system formwork construction in order to achieve the aim and objectives of the study.

3.2 Research Strategy

Research method is defined as the way in which the research objectives can be questioned. It can be classified into two distinct types which is quantitative research and qualitative research. (Richardson et al., 2005)

3.2.1 Quantitative Research

In quantitative research, the information obtained from the respondents is expressed in numerical form, which the quantities of things can be measured such as number of items recalled, reaction times, percentage of items used, etc. Quantitative data can be collected by using a structured questionnaire that contains closed-ended questions. The advantage of quantitative research is less tedious and easy to understand when analyzing quantitative data. Moreover, when the survey involves a convenience sample, the data can be collected and analysed fairly quickly.

3.2.2 Qualitative Research

In qualitative research, the information obtained from respondents is not expressed in numerical form, which cannot be measured quantitatively. Qualitative data can collect by using the method of interview, case study, and observational study. This research can focuses on lifestyle, culture of respondents or behaviour of respondents to other people and environment and so on. Hence, the qualitative research can explore topics in more depth and detail than quantitative research.

3.3 Data Collection

In generally, the data can be classified into primary data and secondary data. Primary data is the data which are collected from the field under the control and supervision of an investigator. This type of data is generally collected for the first time by direct observation. In order for the researchers to get some practical information from the construction industry, there are several methods of data collection such as observation method, personal interview, telephone interview, case study and mail survey can be used by the researchers to collect the primary information.

However, the secondary data is obtained from existing records, publications, etc. This means that the secondary data are collected from sources which have already been created or the purpose of first time use and future use. The secondary data can be obtained from internal sources and external sources. The internal sources of secondary data for marketing applications are sales records, marketing activity, cost information, distributor reports and customer feedback. Where the sources for external sources are from government publications, journals, books, magazines, newspapers, annual reports, etc. (Panneerselvam, 2009)

In this research study, the researcher will use case study and questionnaire to get some practical information from the project manager and the site personnel in the construction site. There are few reasons why the researcher will choose the case study and questionnaire to collect the primary information in this research study.

3.3.1 Questionnaire

The main source of information obtain for data analysis in this research is use the questionnaires method. A success of survey methods is depends on the strength of the questionnaire used. Normally, the questionnaire consists of a set of well-formulated questions to probe and obtain responses from respondents. There are pros and cons of the questionnaire in the primary information. (Panneerselvam, 2009)

Table 3.1: Pros and Cons of Questionnaire Method

Pros	Cons
❖ Less cost of data collection ❖ Less time of data collection ❖ Wider coverage of population ❖ Better accuracy of data ❖ Absence of interviewer's bias	❖ The identity of the respondents is not known to the interviewers. ❖ The questionnaire may be filled in by the assistant. ❖ Source respondents may not return filled in questionnaire. ❖ Delay in returning the filled in questionnaires by respondents.

In addition, there are two primary forms of questions will conducted in this questionnaire survey which is closed ended questions and open ended questions. Closed ended questions will make the respondents' answer are limited to a fixed set of responses. Most scales are closed ended. The latter form of questions is does not give respondents answers to choose from, but rather are phrased so that the respondents are encouraged to explain their answers and reactions to the question. So, the respondents can supplies their own answer without being constrained by a fixed set of possible responses. (Richard & Anita, 2008)

The survey questionnaire will be set by the researcher in order to achieve the objectives, which stated in Chapter1.3. The questionnaire designed for this research is divided into five parts as following:

Part I: Respondent Profile

Respondents were required to indicate their personal information for further reference but this section is optional for them to fill in.

Part II: Project Information

Determine the type of project was currently undertaken by the respondent's company and total number of projects which has involved in the past 5 years in the respondent's company.

Part III: Types of Material Wastage

The respondents were required to indicate the percentage of material wastage normally allowed in a construction project and which type of material is the highest material waste in the construction site.

Part IV: Causes of Construction Wastage

Investigate the causes contributing material wastage occurred frequently on respondent company projects. This question was rated from "strongly agree" (1) to "strongly disagree" (5) by using five-point rating scale.

Part V: Waste Prevention Methods

This section is attempted to find out the most effective waste prevention method which the respondent's company used to solve the material wastage problems in the current project. Simultaneously to figure out whether the respondent's company adopt the table form and tunnel form construction method in the construction site.

3.4 Data Analysis

After data are collected, there are several techniques have been used to analyze the survey data as shows in the followings:-

3.4.1 Descriptive Statistics Method

The descriptive statistics method will be used by researcher to classification and analysis of data. The purpose of using the descriptive statistics method is to have a general overview of the results obtained from construction industry. Therefore, survey questionnaire will be analysis by using percentage and presented by using a bar chart, pie chart or graph according to the data collected.

3.4.2 Conversion of Qualitative Data to Quantitative Data

The survey question 1 in Part IV, respondents was requested to indicate the degree of agrees to the causes of material waste by using the five-point rating scale (from "strongly agree" to "strongly disagree"). For researcher to analysis this question, the qualitative data can be converted to quantitative data by using the following formula:

$$\text{Conversion formula} = \frac{5N_5+4N_4+3N_3+2N_2+N_1}{5(N_5+N_4+N_3+N_2+N_1)}$$

where:

N_5= Number of respondent strongly agree

N_4= Number of respondent agree

N_3= Number of neutral respondent

N_2= Number of respondent disagree

N_1= Number of respondent strongly disagree

3.4.3 Spearman's Rho Correlation Coefficient

The coefficient of correlation between the ranks is a measure of the association between two variables which is determined from the ranks of observations of the variables. The Spearman's coefficient of rank correlation, r is calculated by using the following formula: (Thomas & Grubb, 1986)

$$\text{Rank correlation, } r = 1 - \frac{6\sum di^2}{n(n^2-1)}$$

where:
$\sum di^2$ = sum of the squares of the differences
n = number of data points

The *r*-value can be further interpreted in term of strength of relationship between the variables, which the number varies will between -1 and +1.

- A correlation coefficient of +1 means perfect positive correlation.
- A correlation coefficient close to 0 means no correlation.
- A correlation coefficient of -1 means perfect negative correlation.

3.5 Conclusion

As a conclusion, raw data will be collected by using survey questionnaire and the methods of analyzing the raw data will be descriptive statistics method, conversion of qualitative data to quantitative data and spearman's coefficient of rank correlation. Sending out the questionnaire will be the next stage before analyses the results from the respondents. Furthermore, the material wastage level of conventional and cast in-situ system formwork construction will be evaluated and analysed as a result in this research study.

CHAPTER 4

DATA ANALYSIS

4.1 Introduction

Data analysis will mainly focus on the analysis of the questionnaire survey results from the construction industry. The total of 50 sets of questionnaires were handed over to the respondents by approached them directly. Finally, 33 sets of questionnaire had been collected successfully.

Numbers of questionnaire survey were conducted with the developer firms, consultancy firms, contractor firms in the construction industry in order to achieve the aim and objectives of the research which is determine the types of material wastage, identify the causes of construction waste, and establish the waste prevention methods between conventional and cast in-situ system formwork constructions. Based on their opinions and experience towards construction management, it will be reliable for the purpose of the research.

4.2 Analysis of the Results

Data analysis on survey questionnaire collected from respondents for this research was classified into five parts as 1) respondent profile, 2) project information, 3) type of material waste, 4) causes of construction waste, and 5) waste prevention methods. The detail data analysis and discussion are elaborated as follows:-

4.2.1 Respondents' Profile

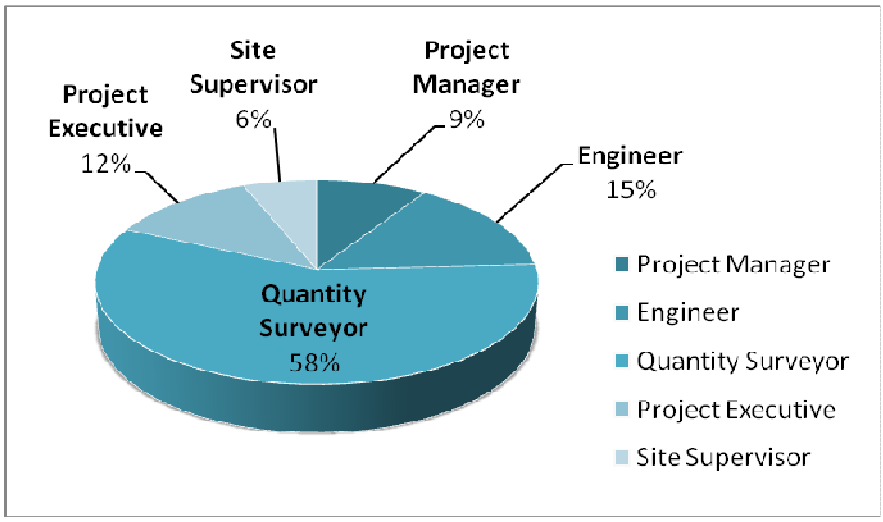


Figure 4.1 Position of Respondents

Based on 33 returned questionnaires, most of the respondents are quantity surveyor which is 58%. Followed by 15% of the respondents are engineer, 12% of the respondents are project executive, 9% of the respondents are project manager and 6% of the respondents are site supervisor.

As the result shows in the above, the majority of the respondents are quantity surveyor and minority of the respondents are come from top management levels, as theses may affect the accuracy of the result.

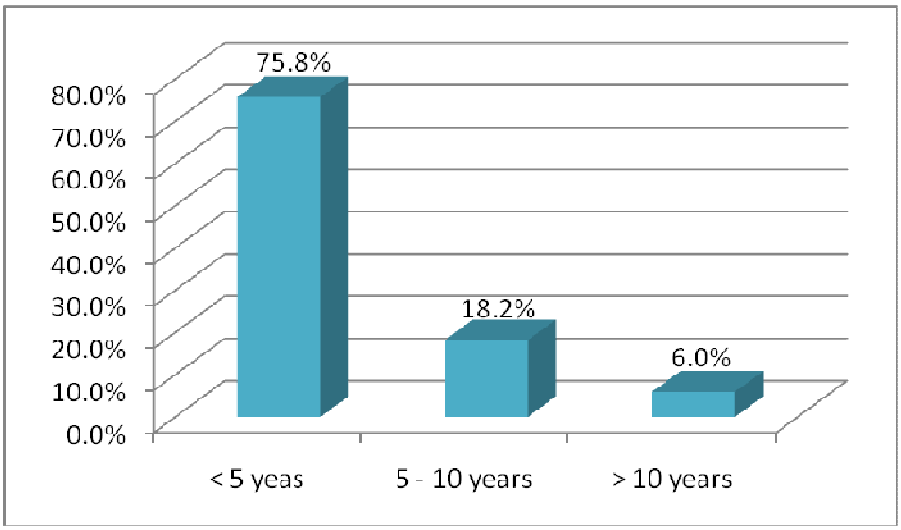


Figure 4.2 Years of Working Experience

As shown in Figure 4.2, the majority of the respondents have the working experience in the construction industry are not more than 5 years which is 75.8% of the respondents. Followed by 18.2% of the respondents have 5 years to 10 years of working experience in the construction industry. The remaining 6% of the respondents have more than 10 years of working experience in the construction industry.

Obviously, the more extensive of working experience in the construction field which the respondents have, the reliability of opinions of respondents are further enhance, these due to the accumulation of knowledge and skill.

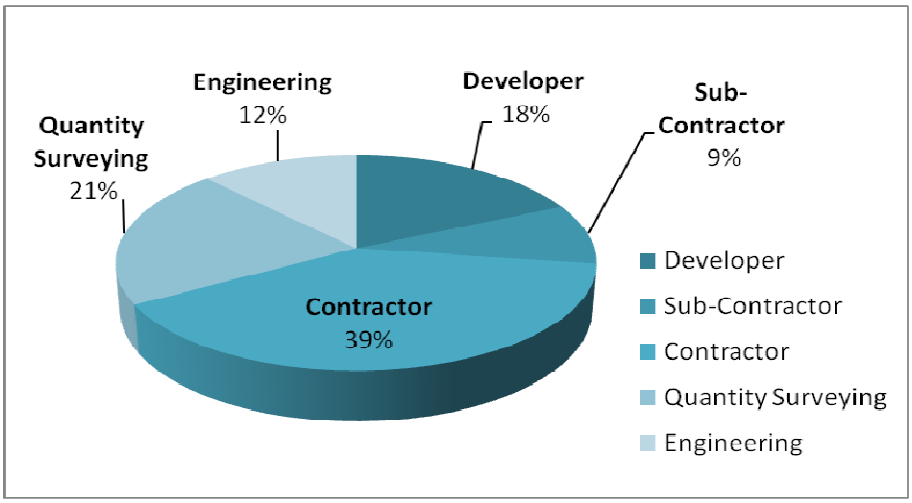


Figure 4.3 Respondent's Nature of Business

As illustrated in Figure 4.3, most of the respondents are working for contractor firm which is 39%. Following respondents are come from consultancy firms where 21% of the respondents are working for quantity surveying firm, and 18% of the respondents are working for developer firm. Following respondents are working for engineering firm which is 18% and 9% of the respondents are come from sub-contractor firm.

As the result of analyse shows above, the respondents are equally who come from the contractor firms and consultant firms, as theses may provide accurate data analyse due to the equally opinion from both parties.

4.2.2 Project Information

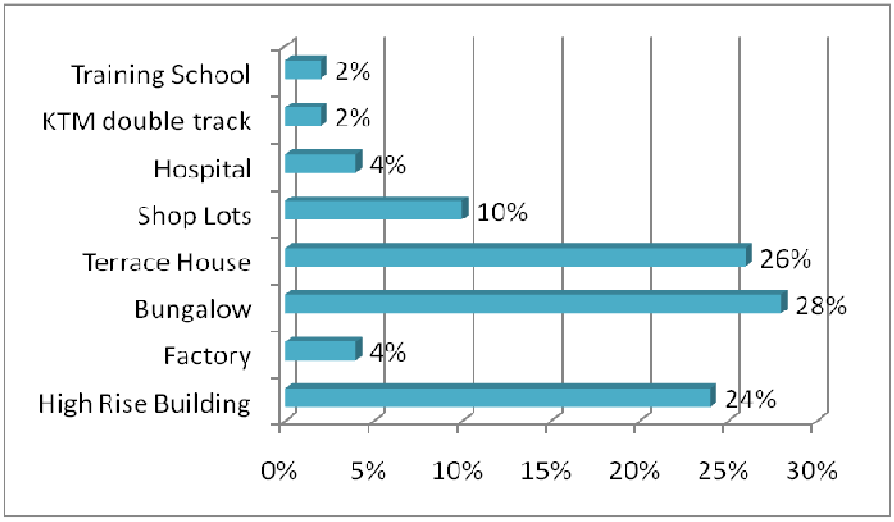


Figure 4.4 Type of Projects are Currently Undertaking

From the questionnaire survey results gathered from the construction industry, the majority type of projects are currently undertaking by respondents is bungalow which is 28%. Following by 26% of the respondents are currently handled the terrace houses project, 24% of the respondents currently handled the high-rise buildings projects, and 10% of the respondents currently handled the shop lots projects. Following by 4% of the respondents currently handled the hospital projects, 4% of the respondents currently handled the factory or warehouse projects, 2% of the respondents currently handled the training school project. The remaining 2% of the respondents are currently handled the KTM double track projects.

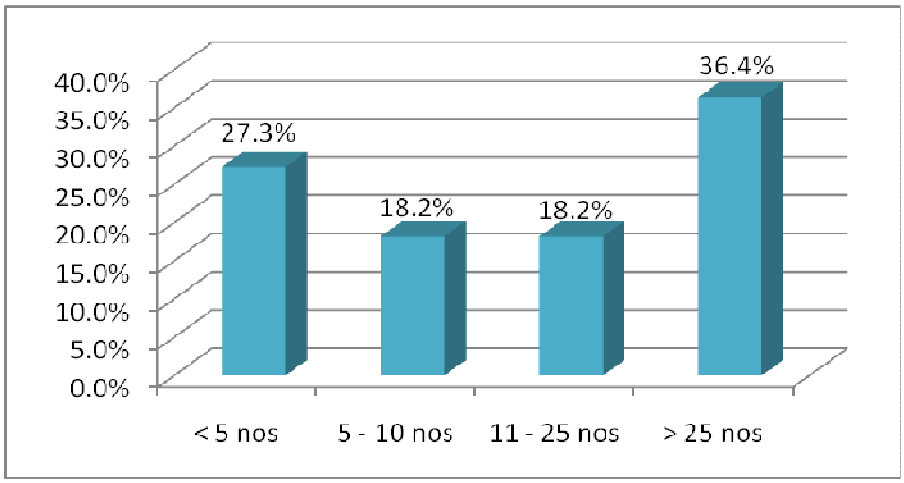


Figure 4.5 Number of Projects have been Involeved in the Past 5 Years

In Figure 4.5 shows that the total number of projects have been involved by respondents' company from year 2005 until 2010. From the questionnaire survey results gathered from the construction industry, 36.4% of the respondents' have the opinions that their respective company have been involved more than 25 numbers of projects in the past 5 years. Following by 27.3% of respondents' have the opinions that their respective company in the past 5 years have been involved not more than 5 numbers of projects. Following by 18.2% of respondents' have the opinions that their respective company in the past 5 years have been involved 5 to 10 numbers of projects. Lastly, the 18.2% of respondents' have the opinions that their respective company have been involved 11 to 25 numbers of projects in the past 5 years.

4.2.3 Type of Material Wastage

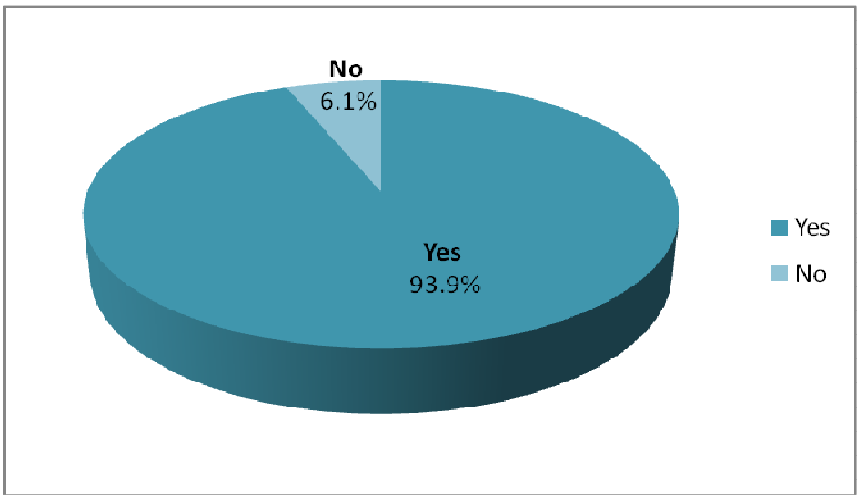


Figure 4.6 Level of Seriousness of Material Wastage

The aim of this question is to get the respondents' opinions about the reasons of seriousness of material wastage problems in the construction industry. From the questionnaire survey results gathered from the construction industry, 93.9% of the respondents have the opinions that the material wastage problems are serious in the construction industry. The results gathered from the construction industry are same with the information stated in the literature review chapter because of the inexperience of contractors in construction management and irresponsibility by the contractors creates a lot of rubbish. On the other hand, 6.1% of the respondents have the opinions that the material wastage problems are not so serious in the construction industry. These category of respondents have this opinions that because of the new construction methods and better practice in construction had apply and new innovation of products had invented to solve the material wastage problems in construction industry.

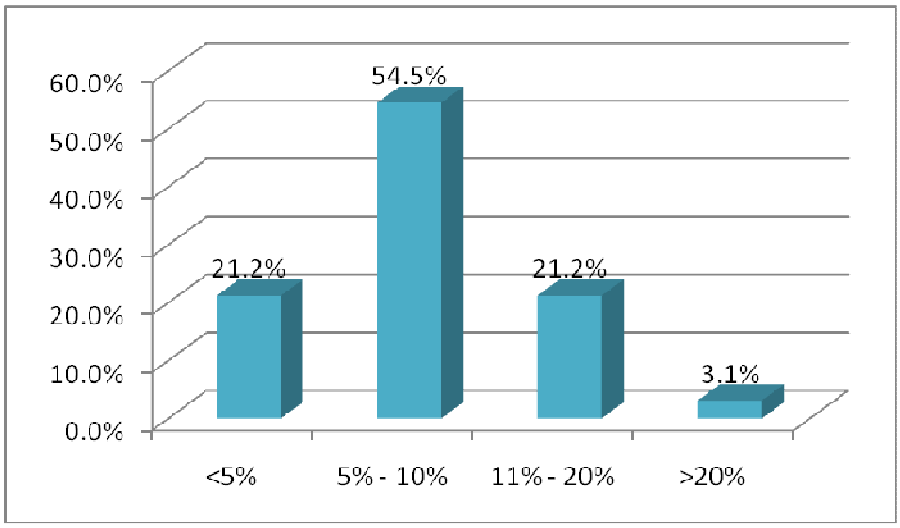


Figure 4.7 Percentage allowed for Material Wastage

The aim of this question is to find out the percentage allowed for material wastage in a construction project. From the questionnaire survey results gathered from the construction industry, 54.5% of the respondents have the opinions that their respective company were allowed 5% to 10% of material wastage for every construction project. According to the respondents, 10% of material wastage is more than enough for their currently projects. Following by 21.2% of the respondents have the opinions that their respective company will allowed below 5% of material wastage for every construction project. According to the respondents, below 5% of material wastage is enough for small and medium projects. Another 21.2% of the respondents have the opinion that their respective company were allowed 11% to 20% of material wastage for every construction project. The remaining 3.1% of the respondents have the opinions that their respective company will allowed more than 20% of material wastage for every construction project. According to the respondents, the percentage allowed for material wastage in a construction project is depends on the site condition and the complexity of the design. The more the percentage allowed for material wastage, the lower the profit margin and the attitude of workers towards reducing the material wastage will be affected.

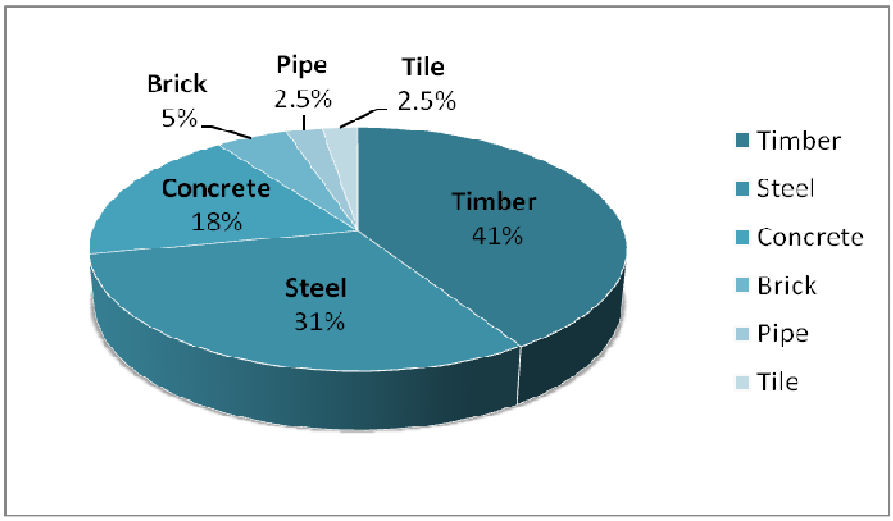


Figure 4.8 Material Wastage Levels between 6 Types of Construction Material

The aim of this question is to find out the materials which the material level is the highest in the construction site. From the questionnaire survey results gathered from the construction industry, 41% of the respondents have the opinions that the timber was the highest material wastage in construction site because of the nature of timber which easily warp and defective when exposed to weather. Secondly is 31% of the respondents have the opinions that the steel was the one of the major material wastage in construction site because of the nature of steel which easily corroded and improper cutting of steel bars causes wastage. Following by 18% of the respondents have the opinions that the concrete was another one of major material wastage in construction site because of the excessive ordering by inexperience site personnel and poor workmanship during concreting. Following by 5% of the respondents have the opinions that the brick was the one of the major material wastage in construction site because of the nature of brick which easily broken when exposed to weather and improper storage. The following 2.5% the respondents have the opinions that the pipe was the one of material wastage in construction site, where the remaining 2.5% of the tile waste was also one of waste streams in construction site. The results gathered from the construction industry are slightly different with the information stated in the literature review chapter which are wood is 64%, concrete is 20.7%, brick is 9.1% , metal is 2.5% and others is 3.7%. These differences may be caused by the different location of construction site.

4.2.4 Causes of Construction Waste

Table 4.1: Causes of Material Wastage in Construction Site

	Causes	1	2	3	4	5	Important Index	Rank
i.	Faulty Workmanship	6	18	6	3	0	0.7636	1
ii.	Design changes	6	14	10	2	1	0.7333	2
iii.	Inappropriate storage	3	15	10	4	1	0.6909	3
iv.	Communication Problems	3	15	8	5	2	0.6727	4
v.	Unfriendly attitudes of project participants	1	15	11	6	0	0.6667	5
vi.	Lack of information in the drawings	3	13	7	8	2	0.6424	6
vii.	Poor quality of material	2	9	11	11	0	0.6121	7
viii.	Damage during Transportation	1	8	17	6	1	0.6121	7
ix.	Weather Problems	1	7	17	6	2	0.5939	9
x.	Ordering errors	5	2	10	15	1	0.5697	10

Note: 1-Strongly Agree, 2-Agree, 3-Neutral, 4-Disagree, and 5-Strongly Disagree

As shown in Table 4.1, the majority of respondents have the opinion that faulty workmanship was rank as the most critical causes which will affecting the material wastage in the construction site. According to the literature review, *faulty workmanship* occurs frequently in the construction site due to inexperience of the workers during carry out the works and human mistake during reading the construction drawings.

Following by *design changes* are rank as the second highest of causes to affecting the material wastage which occurs frequently in the construction site. During the design stage, many people are involved and the possibilities of miscommunication between the design consultants are high and the possibilities of miss out in design will also increase.

Following by *inappropriate storage* are rank as the next causes for affecting the material wastage in the construction site. The result shows that the inappropriate storage occurs frequently in the construction site due to raw materials stored in unsuitable places with high moisture, on soft soil and other conditions which causes deterioration of materials. Next, the respondents have the opinion that the causes for affecting the material wastage occur frequently in the construction site are *communication problems, unfriendly attitudes of project participants* and *lack of information in the drawings.*

Furthermore, the respondents have the opinion that *poor quality of material* and *damage during transportation* are rank as the next causes for affecting the material wastage in the construction site. According to the literature review, damage during transportation occurs frequently in the construction site due to improper planning during unloading of materials and cause double handling of materials.

Following by *weather problems* are rank as the next causes for affecting the material wastage in the construction site. Lastly is the *ordering errors* occurs frequently in the construction site due to excessive ordering of material causes surplus of material. The results gathered from the construction industry are almost the same with the information stated in the literature review chapter.

Table 4.2: Frequency of Causes of Material Wastage in Different Nature of Business

	Causes	Developer	Consultant	Contractor	Sub-Con
i.	Faulty Workmanship	7.5	1	2	5.5
ii.	Design changes	7.5	8	7.5	5.5
iii.	Inappropriate storage	5.5	3	6	10
iv.	Communication Problems	3.5	10	10	9
v.	Unfriendly attitudes of project participants	3.5	9	9	5.5
vi.	Lack of information in the drawings	1	5.5	4.5	2.5
vii.	Poor quality of material	5.5	5.5	3	5.5
viii.	Damage during Transportation	2	2	1	2.5
ix.	Weather Problems	7.5	4	4.5	1
x.	Ordering errors	10	7	7.5	2.5

As indicated in Table 4.2, the result on frequency of causes of material wastage in different nature of business from respondents, such as the developer, consultant, contractor and sub-contractor. Each natures of business were rank from 1 to 10 according to the frequency of causes of material wastage in construction industry. The table shows that different natures of business were have different rankings on the causes of material wastage in construction industry.

Table 4.3: Causes of Material Wastage of Developer Compared to Consultant Firm

	Causes	Developer	Consultant	di	di^2
i.	Faulty Workmanship	7.5	1	6.5	42.25
ii.	Design changes	7.5	8	-0.5	0.25
iii.	Inappropriate storage	5.5	3	2.5	6.25
iv.	Communication Problems	3.5	10	-6.5	42.25
v.	Unfriendly attitudes of project participants	3.5	9	-5.5	30.25
vi.	Lack of information in the drawings	1	5.5	-4.5	20.25
vii.	Poor quality of material	5.5	5.5	0	0
viii.	Damage during Transportation	2	2	0	0
ix.	Weather Problems	7.5	4	3.5	12.25
x.	Ordering errors	10	7	3	9
	Total di^2				**162.75**

$$\text{Rank correlation, } r_1 = 1 - \frac{6\sum di^2}{n(n^2-1)} = 1 - \frac{976.5}{990}$$

$$= \underline{\quad 0.0136 \quad}$$

The data on causes of the material wastage in the construction site will be further analysed by Spearman's coefficient of rank correlation (Richard, & Anita, 2008). As the result shows in the above, the correlation coefficient of 0.0136 is positive correlation. In the frequency of causes of material wastage of developer compared to consultant firm, there is a weak correlation between the two variables.

Table 4.4: Causes of Material Wastage of Developer Compared to Contractor Firm

	Causes	Developer	Contractor	di	di^2
i.	Faulty Workmanship	7.5	2	5.5	30.25
ii.	Design changes	7.5	7.5	0	0
iii.	Inappropriate storage	5.5	6	-0.5	0.25
iv.	Communication Problems	3.5	10	-6.5	42.25
v.	Unfriendly attitudes of project participants	3.5	9	-5.5	30.25
vi.	Lack of information in the drawings	1	4.5	-3.5	12.25
vii.	Poor quality of material	5.5	3	2.5	6.25
viii.	Damage during Transportation	2	1	1	1
ix.	Weather Problems	7.5	4.5	3	9
x.	Ordering errors	10	7.5	2.5	6.25
	Total di^2				**137.75**

$$\text{Rank correlation, } r_2 = 1 - \frac{6\sum di^2}{n(n^2-1)} = 1 - \frac{826.5}{990}$$

$$= \underline{\quad 0.1652 \quad}$$

The result as above shows that the correlation coefficient of 0.1652 is positive correlation. In the frequency of causes of material wastage of developer compared to contractor firm, there is a moderate correlation between the two variables.

Table 4.5: Causes of Material Wastage of Developer Compared to Sub-Contractor Firm

	Causes	Developer	Sub-Con	di	di²
i.	Faulty Workmanship	7.5	5.5	2	4
ii.	Design changes	7.5	5.5	2	4
iii.	Inappropriate storage	5.5	10	-4.5	20.25
iv.	Communication Problems	3.5	9	-5.5	30.25
v.	Unfriendly attitudes of project participants	3.5	5.5	-2	4
vi.	Lack of information in the drawings	1	2.5	-1.5	2.25
vii.	Poor quality of material	5.5	5.5	0	0
viii.	Damage during Transportation	2	2.5	-0.5	0.25
ix.	Weather Problems	7.5	1	6.5	42.25
x.	Ordering errors	10	2.5	7.5	56.25
	Total di²				**163.5**

$$\text{Rank correlation, } r_3 = 1 - \frac{6\sum di^2}{n(n^2-1)} = 1 - \frac{981}{990}$$

$$= \underline{\quad 0.0091 \quad}$$

As the result shows in the above, the correlation coefficient of 0.0091 is positive correlation. In the frequency of causes of material wastage of developer compared to sub-contractor firm, there is a very weak correlation between the two variables.

Table 4.6: Causes of Material Wastage of Consultant Compared to Contractor Firm

	Causes	Consultant	Contractor	di	di²
i.	Faulty Workmanship	1	2	-1	1
ii.	Design changes	8	7.5	0.5	0.25
iii.	Inappropriate storage	3	6	-3	9
iv.	Communication Problems	10	10	0	0
v.	Unfriendly attitudes of project participants	9	9	0	0
vi.	Lack of information in the drawings	5.5	4.5	1	1
vii.	Poor quality of material	5.5	3	2.5	6.25
viii.	Damage during Transportation	2	1	1	1
ix.	Weather Problems	4	4.5	-0.5	0.25
x.	Ordering errors	7	7.5	-0.5	0.25
	Total di²				**19**

$$\text{Rank correlation, } r_4 = 1 - \frac{6\sum di^2}{n(n^2-1)} = 1 - \frac{114}{990}$$

$$= 0.8848$$

The result as above shows that the correlation coefficient of 0.8848 is positive correlation. In the frequency of causes of material wastage of consultant compared to contractor firm, there is a very strong correlation between the two variables.

Table 4.7: Causes of Material Wastage of Consultant Compared to Sub-Contractor Firm

	Causes	Consultant	Sub-Con	di	di²
i.	Faulty Workmanship	1	5.5	-4.5	20.25
ii.	Design changes	8	5.5	2.5	6.25
iii.	Inappropriate storage	3	10	-7	49
iv.	Communication Problems	10	9	1	1
v.	Unfriendly attitudes of project participants	9	5.5	3.5	12.25
vi.	Lack of information in the drawings	5.5	2.5	3	9
vii.	Poor quality of material	5.5	5.5	0	0
viii.	Damage during Transportation	2	2.5	-0.5	0.25
ix.	Weather Problems	4	1	3	9
x.	Ordering errors	7	2.5	4.5	20.25
	Total di²				**127.25**

$$\text{Rank correlation, } r_s = 1 - \frac{6\sum di^2}{n(n^2-1)} = 1 - \frac{763.5}{990}$$

$$= \underline{\quad 0.2288 \quad}$$

As the result shows in the above, the correlation coefficient of 0.2288 is positive correlation. In the frequency of causes of material wastage of consultant compared to sub-contractor firm, there is a moderate correlation between the two variables.

Table 4.8: Causes of Material Wastage of Contractor Compared to Sub-Contractor Firm

	Causes	Contractor	Sub-Con	di	di²
i.	Faulty Workmanship	2	5.5	-3.5	12.25
ii.	Design changes	7.5	5.5	2	4
iii.	Inappropriate storage	6	10	-4	16
iv.	Communication Problems	10	9	1	1
v.	Unfriendly attitudes of project participants	9	5.5	3.5	12.25
vi.	Lack of information in the drawings	4.5	2.5	2	4
vii.	Poor quality of material	3	5.5	-2.5	6.25
viii.	Damage during Transportation	1	2.5	-1.5	2.25
ix.	Weather Problems	4.5	1	3.5	12.25
x.	Ordering errors	7.5	2.5	5	25
	Total di²				**95.25**

$$\text{Rank correlation, } r_6 = 1 - \frac{6\sum di^2}{n(n^2-1)} = 1 - \frac{571.5}{990}$$

$$= \underline{\quad 0.4227 \quad}$$

The result as above shows that the correlation coefficient of 0.4227 is positive correlation. In the frequency of causes of material wastage of contractor compared to sub-contractor firm, there is a strong correlation between the two variables.

4.2.5 Waste Prevention Methods

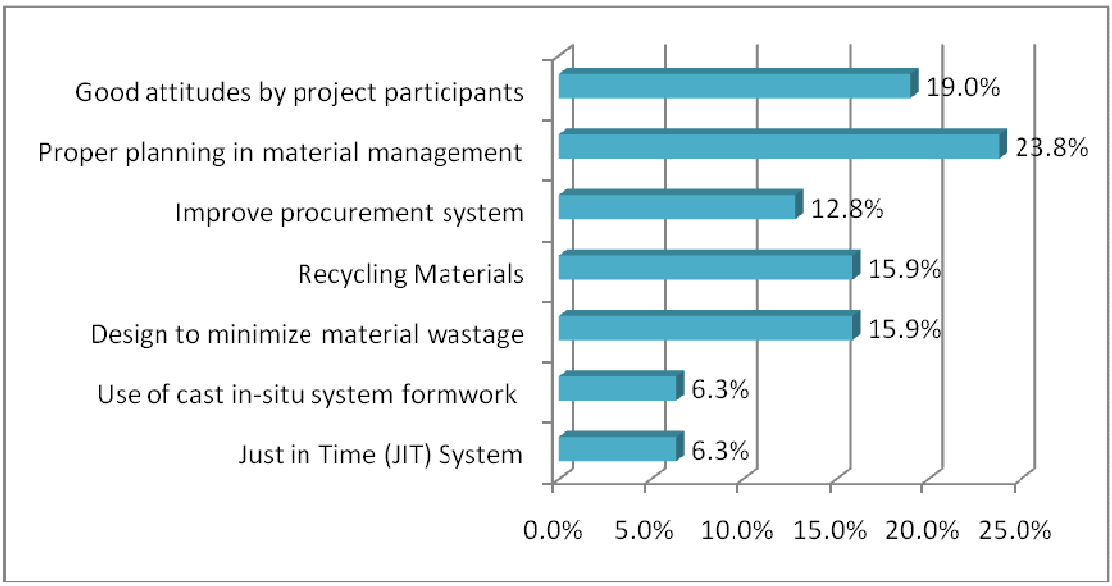


Figure 4.9 Effectiveness of Waste Prevention Methods

The aim of this question is to find out the most effective waste prevention method which the respondents' respective company used to solve the material wastage problems in the construction site. From the questionnaire survey results gathered from the construction industry, 23.8% of the respondents have the opinions that proper planning in material management will solve the material wastage problems effectively in the construction site. Following by 19% of the respondents have the opinions that formation of good attitudes by project participants will solve the material wastage problems effectively in the construction site. Formation of good attitudes by project participants of good attitudes by project participants is the next effective waste prevention method which can reduce the material wastage due to the construction workers do not cherish the materials provided.

Following by 15.9% of the respondents have the opinions that recycling materials and design to minimize material wastage can solve the material wastage problems effectively in the construction site. Design to minimize material wastage is the next effective waste prevention method which can reduce the material wastage due to practical waste, design changes and inadequate information in specifications during the construction period. Following by 12.8% of the respondents have the

opinions that improve procurement system can solve the material wastage problems effectively in the construction site. According to the literature review, improve procurement system can reduce the material wastage due to excess ordering of materials, improper planning during unloading of materials, and causes double handling of materials.

Lastly is 6.3% of the respondents have the opinions that use of cast in-situ system formwork and Just in Time system can solve the material waste problems effectively in the construction site. Choosing proper construction method which plan the sequence of works properly based on the site condition and the complexity of the design can save up time and cost and reduce unpredictable events during construction period hence solve the material wastage problems in the construction site; and adapting Just in Time system which the materials to be used within the shortest period after delivered to site can reduce the material wastage due to theft, storage problems and vandalism in the construction site.

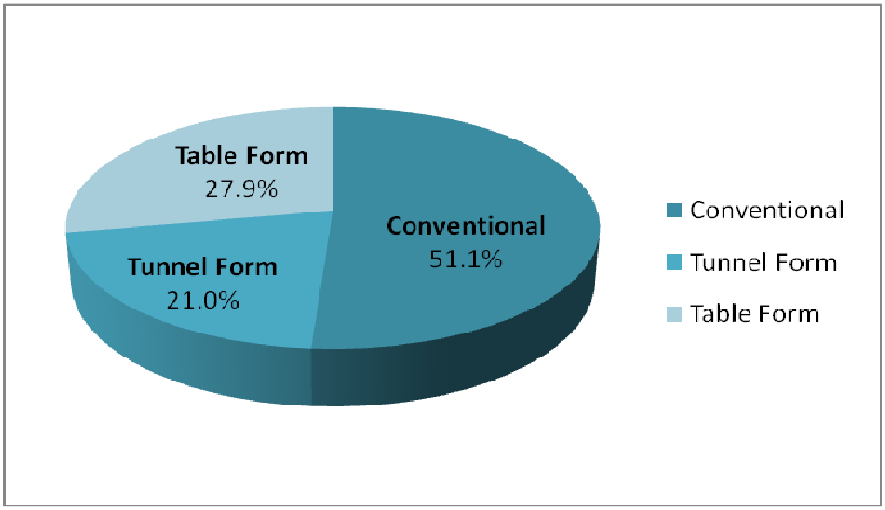


Figure 4.10 Type of Structural Building System

As illustrated in Figure 4.10, the aim of this question is to find out which types of structural building system are the respondents' respective company used in the construction site. From the questionnaire survey results gathered from the construction industry, 51.1% of the respondents have the opinions that his respective company has used the conventional construction in their building projects. Following

by 27.9% of the respondents' respective company used the table form construction in the previous and current projects. Lastly, 21% of the respondents have the opinions that his respective company has used the tunnel form construction in the construction site. According to the respondents, the cast in-situ system formwork construction is normally used in the projects with similar design and need to be completed within the shortest period to prevent losses.

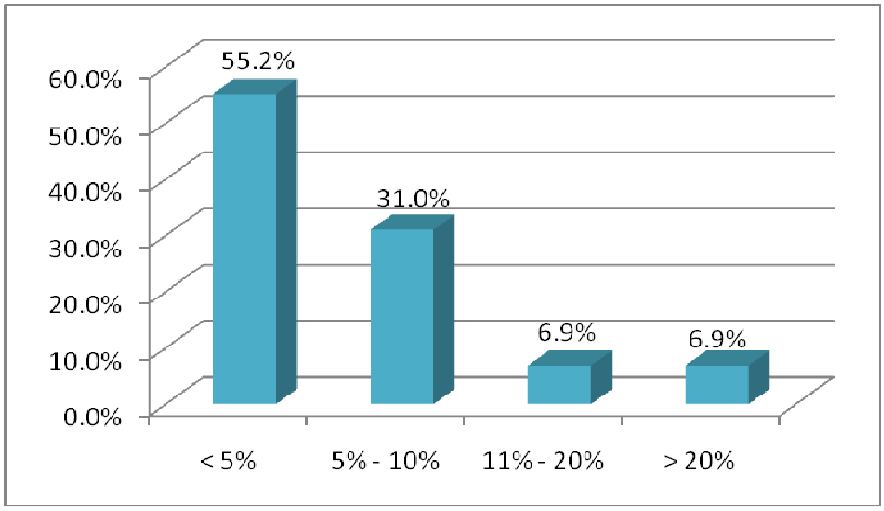


Figure 4.11 Percentage of Material Wastage Prevented by Applying Table Form Construction

As shown in Figure 4.11, the aim of this question is to find out the percentage of material wastage can be prevented by using the table form construction. From the questionnaire survey results gathered from the construction industry, 55.2% of the respondents have the opinions that the percentage of material wastage can be prevented not more than 5% if using the table form construction. Following by 31% of the respondents have the opinions that if using the table form construction, the material wastage can be prevented 5% to 10% for every construction project. Following by 6.9% of the respondents have the opinion that material wastage can be prevented 11% to 20% and more than 20% of material wastage for every construction project if using the table form construction. According to the respondents, if the percentage is merely calculate on the material wastage, there will definitely save up more; if the percentage is calculate on the overall construction cost, there will not save up more.

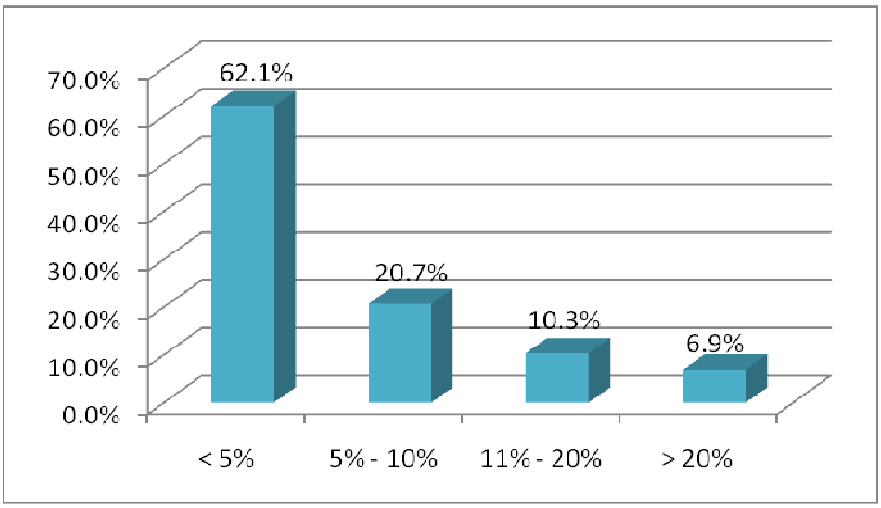


Figure 4.12 Percentage of Material Wastage Prevented by Applying Tunnel Form Construction

The aim of this question is to find out the percentage of material wastage can be prevented by using the table form construction. From the questionnaire survey results gathered from the construction industry, 62.1% of the respondents have the opinions that the percentage of material wastage can be prevented not more than 5% if using the tunnel form construction. Following by 20.7% of the respondents have the opinions that if using the table form construction, the material wastage can be prevented 5% to 10% for every construction project. Following by 10.3% of the respondents have the opinion that material wastage can be prevented 11% to 20% of material wastage for every construction project if using the tunnel form construction. The remaining 6.9% of the respondents have the opinions that material wastage can be prevented more than 20% if using the tunnel form construction. According to the respondents, if the percentage is merely calculate on the material wastage, there will definitely save up more; if the percentage is calculate on the overall construction cost, there will not save up more.

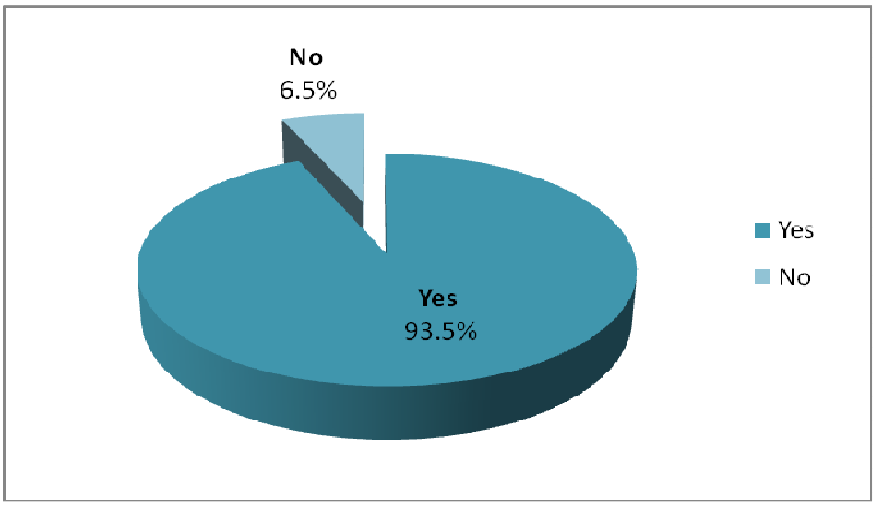


Figure 4.13 Ability of Table Form Construction Solve the Material Wastage Problems

The aim of this question is to get the respondents' opinions about the ability of table form construction to solve the material wastage problems in the construction industry. From the questionnaire survey results gathered from the construction industry, 93.5% of the respondents have the opinions that the table form construction able to solve the material wastage problems in the construction industry. On the other hand, 6.5% of the respondents have the opinions that the table form construction unable to solve the material wastage problems in the construction industry. The results gathered from the construction industry are same with the information stated in the literature review chapter which is the table form construction will be able to solve the material wastage problems in the construction industry.

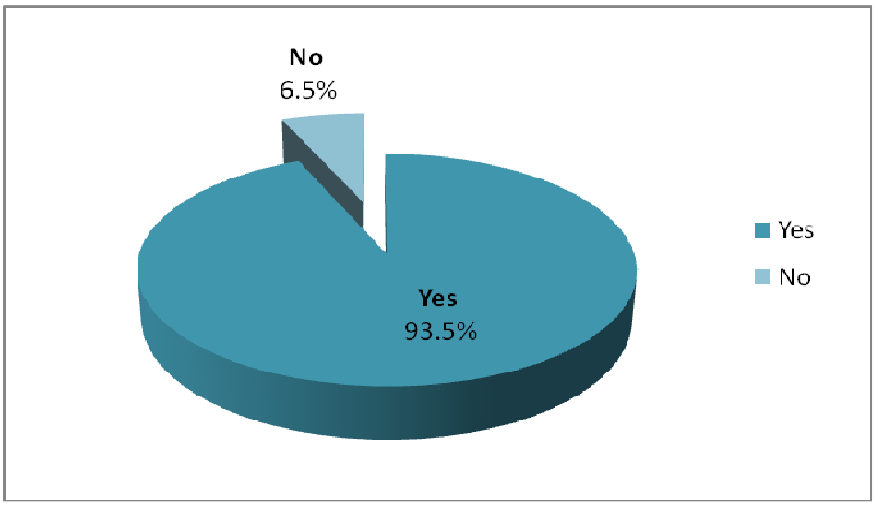


Figure 4.14 Ability of Tunnel Form Construction Solve the Material Wastage Problems

The aim of this question is to get the respondents' opinions about the ability of tunnel form construction to solve the material wastage problems in the construction industry. From the questionnaire survey results gathered from the construction industry, 93.5% of the respondents have the opinions that the tunnel form construction able to solve the material wastage problems in the construction industry. On the other hand, 6.5% of the respondents have the opinions that the tunnel form construction unable to solve the material wastage problems in the construction industry. The results gathered from the construction industry are same with the information stated in the literature review chapter which is the tunnel form construction will be able to solve the material wastage problems in the construction industry.

4.3 Conclusion

As a summary of the research findings, 58% of the respondents' position are quantity surveyor. On average, years of working experience in the construction field that the respondents had was not more than 5 years. Most of the respondents are working for contractor firm which is 39%. Obviously, the more extensive of working experience in the construction field which the respondents have, the reliability of opinions of respondents are further enhancing.

From the questionnaire survey results gathered from the construction industry, 36.4% of the respondents' have the opinions that their respective company have been involved more than 25 numbers of projects from year 2005 until 2010. The majority type of projects are currently undertaking by respondents is bungalow which is 28%.

According to the respondents, 93.9% of the respondents have the opinions that the material wastage problems are serious in the construction industry. 54.5% of the respondents have the opinions that their respective company were allowed 5% to 10% of material wastage for every construction project. From the questionnaire survey results gathered from the construction industry, 41% of the respondents have the opinions that the timber was the highest material wastage in construction site.

The majority of respondents have the opinion that faulty workmanship was rank as the most critical causes to affecting the material wastage in the construction site. According to the literature review, faulty workmanship occurs frequently in the construction site due to inexperience of the workers during carry out the works and human mistake during reading the construction drawings.

As the result of analyse shows, 23.8% of the respondents agreed that proper planning in material management will solve the material wastage problems effectively in the construction site. 51.1% of the respondents have the opinions that his respective company were used the conventional construction method in their building projects. On the other hand, some of the respondents have the opinions that his respective company were used cast in-situ construction in their building projects where the table foam system with 27.9% and tunnel form system with 21%. This

shows that the usage of cast in-situ construction was quite parallel with the conventional construction.

Regarding the data of percentage of material wastage can be prevented in the table form and tunnel form construction, some of the respondents do not provide the information of percentage of material wastage can be prevented, because some of respondents' respective company are not adopting these methods in their construction project and they do not have any experience with those particular construction methods.

Furthermore, 93.5% of the respondents have the opinions that the table form and tunnel form construction able to solve the material wastage problems in the construction industry. In the same time, they deem that the percentage of material wastage can be prevented in their building projects were not more than 5% if using these kinds of construction methods.

It can be concluded that the most of the respondents' respective company are willing to accept the new technologies where table form and tunnel form construction in their future projects. Besides, most of the respondents agreed that these system construction methods are able to solve the material wastage problems in the construction industry. Nevertheless, this does not mean that the respondents are familiar on the construction methods, so may lead respondents deem that the percentage of material wastage can be prevented in their building projects were not more than 5%.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

After the data analysis which has been shown in chapter four, it is found that all the three objectives have been achieved. The conclusion can be drawn from this research study are as follows:-

5.1.1 To Determine the Types of Material Wastage

The types of material wastage have been successfully identified. The types of material wastage determined are shown according to the top three frequency of material wastage:

i. Timber, (41%) – Can be easily cut and shaped but low in durability and reusability, easily warp and defective when exposed to weather;
ii. Steel, (31%) – Easily corroded and improper cutting of steel bars;
iii. Concrete, (18%) – Excessive ordering by inexperience site personnel and poor workmanship during concreting.

5.1.2 To Identify the Causes of Construction Waste

The causes of construction waste have been successfully identified. The causes of construction waste identified are shown according to the top three frequency of material wastage:

i. Faulty Workmanship, (Index: 0.7636) – Inexperience of the workers during carry out the works and human mistake during reading the construction drawing;
ii. Design Changes, (Index: 0.7333) – Possibilities of miscommunication between the design consultants cause miss out in design. Changes of the design made by client and the designer while construction period may caused the previous work done has to be aborted and also resulted huge of material wastage;
iii. Inappropriate Storage, (Index: 0.6909) – Raw materials stored in unsuitable places with high moisture, on soft soil and other conditions which causes deterioration of materials.

5.1.3 To Establish the Waste Prevention Methods in Construction

The waste prevention methods have been successfully establishes. The waste prevention methods established are shown according to the top three effective methods in the construction site:

i. Proper Planning in Material Storage Management, (23.8%) – Proper choosing and adopting the suitable and right management method can minimize the unnecessary waste;
ii. Good attitudes by project participants, (19.0%) – Improve the knowledge of projects participants in waste management and increase the awareness regarding environmental issue;
iii. Recycling materials, (15.9%) – Some of waste materials can be recycled as the brand new materials for other purpose used;

iv. Design to minimize material wastage, (15.9%) – Detailed information of materials taken into account and optimize material use with minimum material wastage.

5.1.4 To Distinct the Material Wastage Levels between Conventional and Cast In-situ System Formwork

From the data analysis shown in chapter four, it is found that the usage of cast in-situ construction (48.9%) was quite parallel with the conventional construction (51.1%) in nowadays. Cast in-situ system formwork construction is normally used in the projects with similar design and need to be completed within the shortest period to prevent losses.

It can be concluded that the cast in-situ system formwork construction able to solve the material wastage problems in the construction industry. 93.5% of the respondents have the opinions that the table form and tunnel form construction able to solve the material wastage problems in the construction industry. By using that the cast in-situ system formwork construction, the construction cost can be save up 100% for bricklaying, plastering and screeding.

5.2 Recommendation

There are several difficulties and obstacles faced throughout the preparation of this research study. The problems encountered had limited the extent of this study and affected the progress of research study.

The respondents briefly give the answer to the researcher without in-depth thinking due to most of the questionnaire surveys are sent by email, and not face to face giving the questionnaire questions. Therefore, the quality of information gathered is affected. Hence, the method for collecting data may change to other types of survey such as interview to the project participants; this may gather more detailed and accurate information.

Due to time and resource constraint, there are just only questionnaire survey had been conducted. Therefore, the results of analysis for this research study cannot be considered as very accurate because it may not reflect the fact. It is recommended that more surveys and observations should be carried out to get more accurate results.

REFERENCES

Ahargrave. (2002). *Worked examples of correlation calculations*. Retrieved July 28, 2011, from http://www.bizerd.co.uk/timeweb/crunching/crunch_relate_illus.htm.

Coolican, H. (2001). *Research methods and statistics in psychology* (3rd ed.). London: Hodder & Stoughton Educational.

Ekanayake, L. L., & Ofori, G. (2000). Strategies for a sustainable built environment. *Construction material waste source evaluation*, 6, 1-6.

Environmental Protection Act. (1990). *Meaning of waste*. Retrieved February 17, 2011, from http://www.legislation.gov.uk/ukpga/1990/43/section/75.

Forster, G. (1989). *Construction site studies production, administration and personnel* (2nd ed.). London: Longman Group.

Franklin Associates. (1998). Characterization of building-related construction and demolition debris in the united states. *Generation of construction and demolition debris,* 94, 2-19.

Griffith, A., & Watson, A. (2006). *Construction management*. Hampshire, UK: Palgrave Macmillan.

Hira, N. A. (1984). *Project management: techniques in planning & controlling construction projects*. New York: John Wiley & Sons, Inc.

Hussey, H. J., & Skoyles, E. R. (1973). Wastage of materials. *Building waste*, 22, 91-94.

Illingworth, J. R. (2000). *Construction methods and planning* (2nd ed.). Abingdon, Oxon: E & FN Spon Press.

Keys, A., Baldwin, A., & Austin, S. (2011). Designing to encourage waste minimisation in the construction industry. *Addressing waste minimisation through design*, 9, 1-9.

Lau, H. H., Whyte, A., & Law, P. L. (2008). Int. J. Environ. Res. *Composition and characteristics of construction waste generated by residential housing project*, 2(3), 261-258.

Magic Survey Tool. (2011). *Introduction of survey questions*. Retrieved June 16, 2011, from http://www.magicsurveytool.com/survey-types/.

Malaysian Nuclear Agency. (2007). *Research methodology*. Malaysia: Nuclear Malaysia.

Panneerselvam, R. (2009). *Research methodology*. New Delhi: PHI Learning Private Limited.

Pichtel, J. (2005). *Waste management practices: municipal, hazardous and industrial.* Boca Raton, FL: Taylor & Francis Group.

Ping, T. S., Omran, A., & Pakir, H. K. (2009). The international conference on administration and business. *Material waste in the Malaysian construction industry*, 6, 257-264.

Richard, F., & Anita, L. (2008). *Research methods for construction* (3rd ed.). Malden, Mass.: Wiley-Blackwell.

Richardson, S., Guru, B. K., Yu, C. M., Wei, K. K., & Pointon, L. (2005). *How to research*. Singapore: Thomson Learning.

Robert, L. P., Clifford, J. S., & Aviad, S. (2006). *Construction planning, equipment, and methods* (7th ed.). New York: McGraw-Hill.

Shaziman, A. M. (2009). The 7th Malaysia construction sector review and outlook seminar. *The construction sector at the onset of the 10th Malaysia plan keynote and opening address*, 7, 1-7.

Shingo, S. (1988). *Non-stock production: the shingo system for continuous improvement.* America, US: Productivity Press.

Skoyles, L. Y., & Skoyles, J. R. (1987). *Waste prevention on site*. London: Mitchell.

Thomas, C., & Grubb, J. R. (1986). *Beyond birding: Field projects for inquisitive birders.* Retrieved August 13, 2010, from http://birdcentral.net/spearman.htm.

Waste Online. (2006). Wood recycling information sheet. Retrieved February 26, 2011, from http://dl.dropbox.com/u/21130258/resources/informationsheets/wood.htm.

Wikipedia. (2011). Construction. Retrieved March 22, 2011, from http://en.wikipedia.org/wiki/Construction.

Wikipedia. (2011). Waste management. Retrieved March 23, 2011, from http://en.wikipedia.org/wiki/Waste_management.

Womack, J. P., & Jones, D. T. (1996). Lean Thinking. New York: Simon and Schuster.

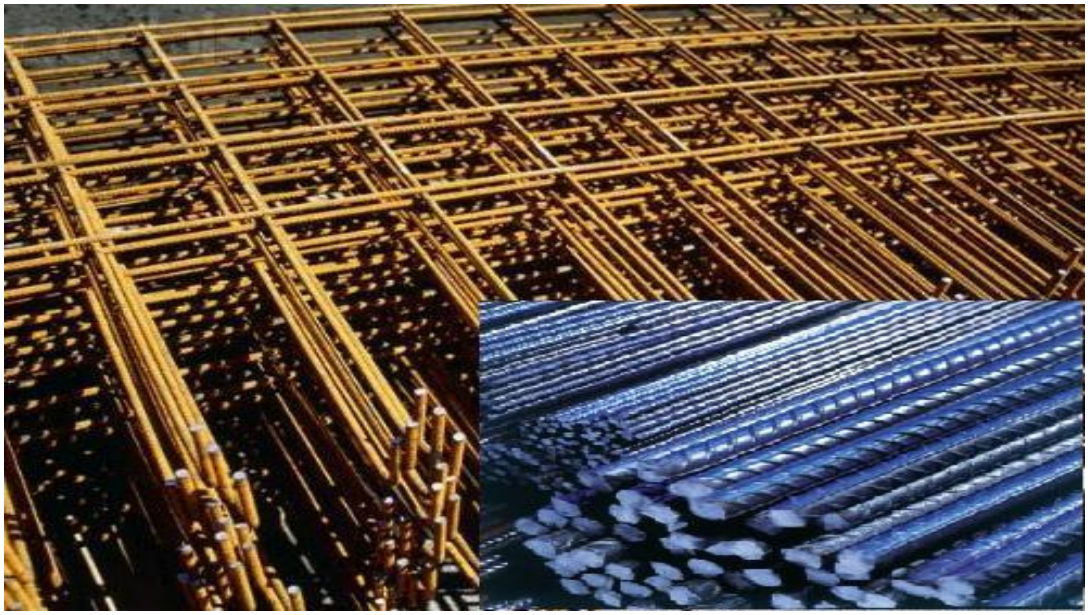
Walker, M. M. (2001). Transfer of lexical information in adults with reading disorders. *Perceptual and Motor Skills*, 93 (1), 257-267.

APPENDICES

APPENDIX A: Questionnaires

APPENDIX B: Pictures

Timber Waste



Steel Waste

Concrete Waste

Brick Waste

Cast In-situ Construction (Table Form Construction)

Conventional Construction