PRACTICES OF REDUCTION, REUSING AND RECYCLING OF SOLID WASTES IN THE MALAYSIAN CONSTRUCTION INDUSTRY

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

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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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APPROVAL FOR SUBMISSION

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Specially dedicated to
my beloved parents

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PRACTICES OF REDUCTION, REUSING AND RECYCLING OF SOLID WASTES IN THE MALAYSIAN CONSTRUCTION INDUSTRY

ABSTRACT

3-R practices have been recognized as an important act in the construction industry as this sector is commonly acknowledged as one with a very high level of waste being generated. This study seeks to identify waste problem in the Malaysian construction field, to investigate reusable and recyclable construction waste materials on site, to identify the degree of 3-R practices in the local construction and also, to explore the advantages of 3-R practices.

A literature review was conducted to collect relevant in-depth information from the research papers that have done by other researchers. Subsequently, a set of open-ended questions was formulated for interview purpose during which the opinions gathered from the interviewees had been summarized accordingly. A great number of survey questionnaire were also distributed to each of the personnel who currently work in Klang Valley or other states for their views.

The survey results established that the use of durable, low maintenance materials is the most effective practice that can contribute to waste minimization and this behaviour is also most frequently practiced among the parties in the industry. Besides, insufficient environmental awareness and concern was ranked as the most significant barrier of waste minimization. It was believed that implementing 3-R practices can create an environmental beneficial to the country.

In short, waste problem must be handled efficiently so as to reduce the negative impact to the environment. To realize these objectives, 3-R practices must be carried out regularly.

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LIST OF SYMBOLS / ABBREVIATIONS

$\bar{x}$	sample mean
μ	specified value to be tested – population mean
SD	sample standard deviation
n	sample size

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CHAPTER 1

INTRODUCTION

1.1 Background

Malaysia is confronting the challenge of construction waste crisis in line with rapid growth of construction sector. Researchers reveal generation of building-related wastes is particularly critical in city areas with intensive urbanization and population concentration. Notwithstanding excess waste is common in every construction stage, most of those involved in the operation pays less consideration on this matter.

Construction waste is considered as a major waste stream in our country. The amount and kind of waste generated depends critically on numerous factors, which are the stage of construction, type of construction work and practices on site. Waste in construction, can sometimes known as non-value adding works. These wastes are intangible. Construction waste is not only associated with material waste, but also related to several activities, for example, overproduction and waiting time (Nagapan et al., 2011).

There are many ways to handle the construction wastes. Dumping of waste to the landfill is a common practice in local communities (Foo et al., 2013). However, this disposal method is not efficient. Landfill spaces in Malaysia are limited and the continuation of disposal of construction waste at landfills would risk to the strategic use of landfills for the disposal of the more demanding waste genres such as hazardous wastes (Yusof, 2006). Thus, practicing reduce, recycling and reuse of wastes is a better, more environmental-friendly solution to manage construction wastes. Throughout these processes, materials resource efficiency is improved and issues like illegal dumping can be minimized to minimum.

1.2 Problem Statement

Undoubtedly, managing waste is no longer appeared as an option but a necessity in most countries. In Malaysia, however, it is clear to notice that current practices do not reflect waste management plan in place. Lack of implementation, lack of effective legislation and technical constraints are the factors contributing towards this disconnect between the plan and practice (Papargyropoulou et al., 2011). Nevertheless, failure to execute source reduction, recycling and reusing of solid wastes is unsustainable as negative impacts to the environment may transpire, for instance, pollution crisis. To run these practices successfully, cooperation between all parties involved in the construction project is essential. By providing adequate training to site staffs can help them to implement a better working procedure to avoid material wastage. To be more effective, waste minimization effort must be integrated into entire construction process and planned at the initial design and tender stages. Always looking for ways to reduce, recycling and reuse solid wastes can contribute to various benefits such as cost and energy savings.

1.3 Rationale of the Research

Waste problem is no longer a new issue in construction sector. Irresponsible management of construction waste gives a negative impact to the environment, cost and time, productivity, and social of country. To avoid these unfavourable consequences, a thorough understanding of the construction waste generation and management is vital. This research is mainly promoting and encouraging the implementation of 3-R practices, which are source reduction, recycling and reuse of solid wastes in construction sector. The study research also highlights the waste problem has becoming critical in local construction industry and therefore identifies that waste management should be an acute issue to be concerned of. In addition, the research has amplified various merits of 3-R practices in both economic and environmental dimensions.

1.4 Aim and Objectives

The aim of this study is to realize 3-R practices in local construction industry. In order to fulfil the aim, the objectives are set as follow:

a. To identify waste problem in the Malaysian construction field.
b. To investigate reusable and recyclable construction waste materials on site.
c. To identify degree of 3-R practices in local construction.
d. To explore the advantages of 3-R practices.

1.5 Scope and Limitation

The scope of the study focuses on the construction waste generation and practices of reduce, recycling and reuse of waste in Malaysian construction industry. The purpose is to divert materials from landfill disposal to the greatest extent. Throughout this study, construction wastes that can be managed for undergoing 3-R practices are recognized. Besides, it also emphasizes how 3-R practices bring about benefits to the local community.

However, this study is only limited to opinions and perceptions of respondents from construction companies due to inability to obtain detailed quantitative data from construction projects for analyses. As a result, the findings may not represent wholly for the entire construction industry in Malaysia.

Additionally, there is insufficient time to carry out more detailed research and difficult to obtain information from place to place due to transportation difficulty.

1.6 Chapter Outline

Chapter 1 introduces a brief context of the research pertaining to material waste problem in local construction field, followed by the problem statement, rationale of the research, aim and objectives, scope and limitation and lastly the chapter outline of the study.

A thorough literature review is carried out in Chapter 2. The first topic gives meaning of waste under different dimensions and categorizes waste into direct and indirect forms. The next topic identifies the waste problem in Malaysian construction industry by adopting the case study done by other researchers. Some material wastes that can be reused and recycled are also specified subsequently and different waste management options are introduced for application. The last topic has shown the numerous benefits of implementing reduce, recycling and ruse of waste in construction sector. In these topics, some critical points are included.

Chapter 3 describes the theoretical aspect of research methodology whereby some approaches has been employed to carry out this research to data collection. Moreover, research design also explains how survey questionnaire and interview being conducted to collect information.

In Chapter 4, the results obtained from the survey research will be evaluated, followed by summary of interviewee's perception with some critical comments attached with.

Lastly in Chapter 5, the conclusion and recommendation of the study will be covered.

CHAPTER 2

LITERATURE REVIEW

2.1 What is Construction Waste?

Construction waste is meant by any discarded product or material that is generated from the construction, remodelling, and renovating of building structures. In addition, it is the divergence in value between those delivered and received on site and those utilized appropriately as they are specified and accurately measured in the work, after subtracting the cost saving of substituted materials and any materials transferred elsewhere (Nagapan et al., 2012). Based on the definition given by Telford (1995), he stated that the material is considered as waste once it is abandoned by its manufacturer, despite of how the person who is having the material thinks it is of value. This statement is not satisfactory as Serpell and Alarcon (1998) argued that the unwanted materials can only be termed as “waste” if they have no residual value. Additionally, Turkish researchers name construction wastes as those surplus materials that are left over during or after construction activities, for instance, demolition and renewal of a building structure (Altuncu and Kasapseckin, 2011). Similar definition is given by Tom Napier (2012), which annotates construction waste as residue produced by reason of the implementation of various construction activities, which including scrap, broken or damaged products, temporary and expendable building materials, aids that are excluded in completed project, packaging products and waste caused by manpower. Both declarations have concluded that construction waste is any excess substance by-product of construction works. Some of them may undergo resource recovery for the purpose of waste minimization or otherwise been disposed in landfills.

2.1.1 Categorization of Construction Waste

Skoyles and Skoyles (1987) declare waste resulting from construction activities can be classified as natural waste, direct waste, indirect waste and consequential waste. Both of them recognized those wastes which are unavoidable on construction site and therefore can be accepted as natural waste. Direct waste is a total loss of material due to its irreparable damages and cannot be used for further usage or lost during the building process. This is the waste which is preventable and involves actual loss. By contrast, indirect waste, which is also known as cost waste, is considered as material that is not generally lost physically, but indirectly and involves merely a monetary loss. Cost of wasted materials is usually greater than their value. These extra cost involved with construction waste is related to consequential waste where they are normally hidden (Rameezdeen, n.d.). For example, in case of rework due to design change will cause additional cost incurred for purchasing new materials and delay in completing the project. The delay will further cause an extended hiring time of machinery, professionals and labour which add cost to the contract sum. These additional costs are called consequential waste (Urio and Brent, 2006:19)

Table 2.1 shows various forms in which direct waste can arise in the construction industry.

Table 2.1: Direct Waste

Direct Waste	**Description**
Deliveries waste	Losses in transit to site, unloading and placing into initial storage.
Site storage and internal site transit waste	Losses due to poor stacking and initial storage, including movement and unloading around the site, to stack at workplace or placing into position.
Cutting and conversion waste	Occurs due to cutting materials to size and uneconomical shapes.
Fixing waste	Losses due to materials damaged or discarded during fixing process.
Application waste	Occurs with most wet building materials such as plaster, paint and glue.
Management waste	Occurs due to poor organization or lack of supervision.
Criminal waste	Losses by reason of stealing and vandalism.
Waste caused by other trades	Losses caused by events such as "borrowing" by trades for purposes other than work and no sending back or damage by succeeding trades.
Waste due to erroneous type or quality of materials	Waste stemming from materials specified in wrong way and mistakes found in bills of quantities or specification.
Waste due to uneconomical use of plant	Occurs when the plant or machinery is not operated optimally or being used when not necessary.
Learning waste	Waste owing to lack of experience and poor skill of labour force.

(Source from Urio and Brent, 2006:19)

Table 2.2 lists down several types of indirect waste that may occur throughout construction process.

Table 2.2: Indirect Waste

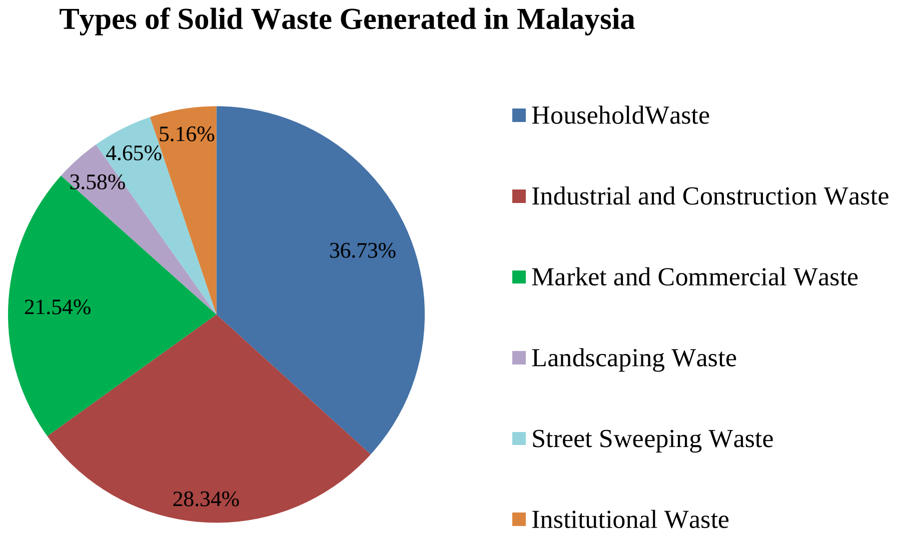
Indirect Waste	**Description**
Substitution waste	Resources are utilized for purposes other than those specified.
Production waste	Excess materials being used due to unavailability of appropriate size of certain materials.
Operational waste	No proper quantities or allowances in contract document for those materials which are used for temporary site work.
Negligence waste	Occurs where more materials are used as a result of use of unsuitable plant or contractor's own negligence.

(Source from Urio and Brent, 2006:19)

2.2 Waste Problem in Malaysian Construction Industry

There is no doubt that construction waste has becoming a common global issue to be discussed nowadays. Especially in urban areas, this kind of waste is a serious environmental problem that can significantly influence the success of construction projects (Nagapan et al., 2012). Increasing urban growth and its metabolism process in Malaysian cities lead to considerable amount of waste generated mainly from household and industries. The solid waste accrued in Malaysia amounted from 16,200 tonnes per day in 2001 to 19,100 tonnes in 2005 or an average of 0.8 kilogram per capita per day (Mohamed et al., n.d.). The rising market demands for various infrastructure, commercial and housing development projects in this country have caused construction sector to create large quantities of unwanted materials, which mean wastes. By reason of bulky wastes has been produced in Malaysian construction industry, the effort of minimizing construction wastes gains to be an imperative issue (Begum et al., 2006). Every project participant owns the responsibility to take part in minimizing waste in order to conserve a healthier environment.

Due to its closed linkage with other industries such as building material manufacturers, construction industry can be described as a substantial economic driver for Malaysia. Previous statistical data shows that construction and demolition (C&D) debris commonly contribute to approximately 10-30% of the waste collected at many landfill sites around the world (Fishbein, 1998). The result of this research is supported by Hassan et al. (1998), which the study is carried out based on Central and Southern region of Malaysia, that proves on average, the breakdown of waste generation with its source: household waste constitutes 36.73%, industrial and construction waste constitutes 28.34%, and the residual 34.93% is remaining to other sources such as institutional waste, market and commercial waste, landscaping waste and street sweeping waste. Furthermore, the findings done by Loosemore and Teo (2001) also shows that construction and demolition waste in Canada is accounted for 30% of solid waste, while in United States, the percentage is estimated to be 20%.



(Source from Hassan et al., 1998)

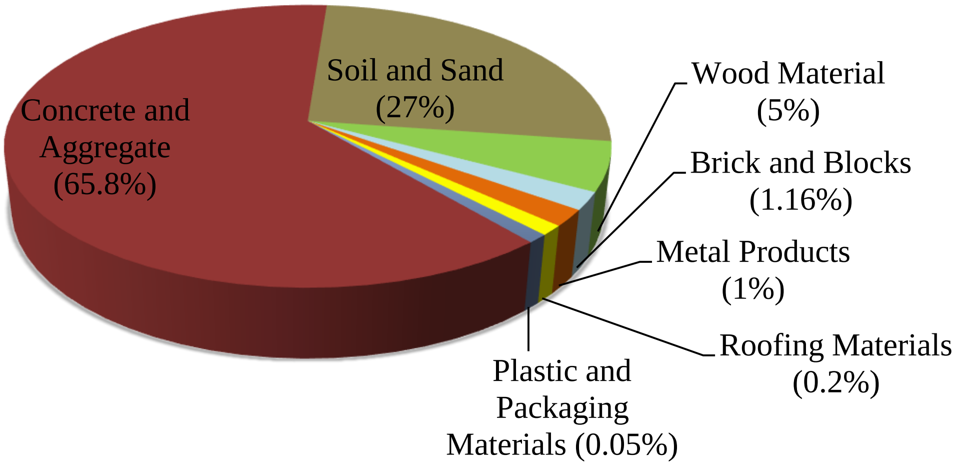
Figure 2.1: Percentage of Various Types of Solid Waste Generated (t/day) in Year 1994

Figure 2.1 shows respective percentage of different types of solid waste generated in Malaysia. The pie chart is illustrated based on the result of the research. From this, it shows that construction waste is considered as second highest in solid waste generation in our country. In spite of the public has paid close attention on the effort to minimize construction waste for many years ago, however, this matter seems becoming worse. According to Hwang and Yeo (2011), the quantity of waste which is produced by construction industry increases, which is about four times of that generated in households and more than 50% disposed of in landfills. In order to reduce construction waste, the “3-R”- reduce, recycling and reuse must be put into practice properly and regularly.

2.3 Reusable and Recyclable Construction Waste Materials on Site

Almost all job site wastes are reusable and recyclable. Appliances, furniture, plumbing fixtures and non-ferrous materials such as copper and brass may have value in secondary markets when one is available. Tom Napier (2012) emphasizes the importance of assessing wastes that may be encountered on projects in developing a comprehensive waste management plan at the project level.

Figure 2.2 below illustrates the composition of each construction waste materials on the site located in Universiti Kebangsaan Malaysia (UKM), Bangi, Selangor which is percentage by weight. This study is carried out by Begum et al. (2006) where the estimated total construction waste generation from this project site is 27068.40 t (tonnage). Concrete and aggregate is the highest rank with 65.8%, followed by soil and sand which contributes to 27%, 5% comes from wood products, 1.16% from brick and blocks, 1% from metal products, 0.2% from roofing materials and the remaining 0.05%, the least composition of waste will be plastic and packaging materials (Begum et al., 2006).



(Source from Begum et al., 2006)

Figure 2.2: Composition of Construction Waste Materials Produced on the Site

Table 2.3: Estimated Construction Waste Generation and Composition on the Site

Construction Waste Materials	**Amount of Waste Generated (t)**
Soil and sand	7290
Brick and blocks	315
Concrete and aggregate	17820
Wood	1350
Metal products	225
Roofing materials	54
Plastic	13.5
Packaging materials	0.90
Total	27068.4

(Source from Begum et al., 2006)

Table 2.4: Amount of Reused and Recycled Construction Waste Materials on the Site

Construction Waste Materials	Amount of Reused and Recycled	
	Tonnage	Percentage (%)
Soil and sand	5400	27.33
Brick and blocks	126	0.64
Concrete and aggregate	13365	67.64
Wood	810	4.0
Metal products	54	0.27
Roofing materials (tiles)	5.4	0.03
Total	19760.4	100

(Source from Begum et al., 2006)

Table 2.3 shows the estimation of the composition of construction waste production in building site. The estimated overall construction waste generation is based on material types, which include soil and sand, brick and blocks, concrete and aggregate, wood, metal products, roofing materials, plastic and packaging materials. Table 2.4 demonstrates the amount of reused and recycled construction waste materials on the building site. Based on the result, concrete and aggregate is amounted to 67.64%, which is considered as the highest amongst others, followed by soil and sand with 27.33%, 4% by wood, 0.64% by brick and blocks, 0.27% by metal products and 0.03% by roofing materials (Begum et al., 2006).

2.3.1 Concrete

Concrete is a common building material found in construction sector. It is made of cement and other cementitious substances such as aggregates, water, sand and chemical admixtures. The waste rate of concrete is found to be high as a result of overproduction, loss resulting from mixing material on bare ground and leak during transportation and placing (Urio and Brent, 2006:19). Waste concrete materials usually obtained after demolition and destruction works (Altuncu and Kasapseckin, 2011). Tom Napier (2012) gives an advice to characterize painted concrete and concrete that already contaminated with wastes prior to recycling. Concrete is crushed and embedded metals are removed. Rocks and cement pieces will then be crushed, screened and segregated to yield aggregates in different dimensions.

Concrete recycling has lower environmental impact by helping on saving energy compared to mining, processing and hauling new aggregates. In addition, recycling concrete from demolition work could save cost of transportation to the landfill and reduce disposal cost to the minimum (Stella, 2011).

2.3.2 Timber

Timber, or wood, is relatively inexpensive, strong, and lightweight. It can be easily cut or shaped for various building purposes, especially on formwork usage. Foo et al. (2013) indicates the timber formwork can be used for three times at minimum before it is disposed.

Wood materials make up about half of the construction waste stream where most timber is generated from the demolition sector. In order to cut cost of collection and disposal, contractors tend to reuse lumber materials, if possible, in their construction works. Timber can be sold through timber brokers to be cleaned and resold for timber framing. Notwithstanding some recycling of wood waste is carried on, the predominant use for sorted wood waste is incineration for co-generation (Johnston and Mincks, 1994). It means the wood waste is not recycled but recovered by processing into feedstock for high quality architectural millwork (Napier, 2012).

2.3.3 Brick

Bricks have a long lifespan, which more than 200 years. It remains as a dominant material used for constructing walls, buildings, paving and infrastructure. These embrace clay bricks, concrete precast, aerated blocks and stone blocks.

A large proportion of construction and demolition (C&D) waste on new residential construction sites is occupied by bricks (Forsythe and Mate, 2007). Due to its brittle nature, bricks are easily being damaged or broken. High waste rate of bricks is mainly because of inaccurate brick cutting, improper handling, irresponsible loading and off-loading and unsuitable lifting equipment (Viljoen, 2010).

2.3.4 Metal

Metal is clustered into ferrous and non-ferrous, for example, aluminium, stainless steel, brass alloys, copper and others. Their characteristics comprise of high tensile strength, malleable and ductile. Structural steel and metal are almost universally recycled and appeared as the highest diversion rate among all the recoverable materials (Tom Napier, 2012).

Altuncu and Kasapseckin (2011) found that recovery of used steel saves 74% of energy and 90% of raw materials. Moreover, water consumption is lessened up to 40%. Significant decrease in pollution of waste water (76%), pollution of air (86%) and waste of materials (97%) certify the importance of recovery of metal construction wastes.

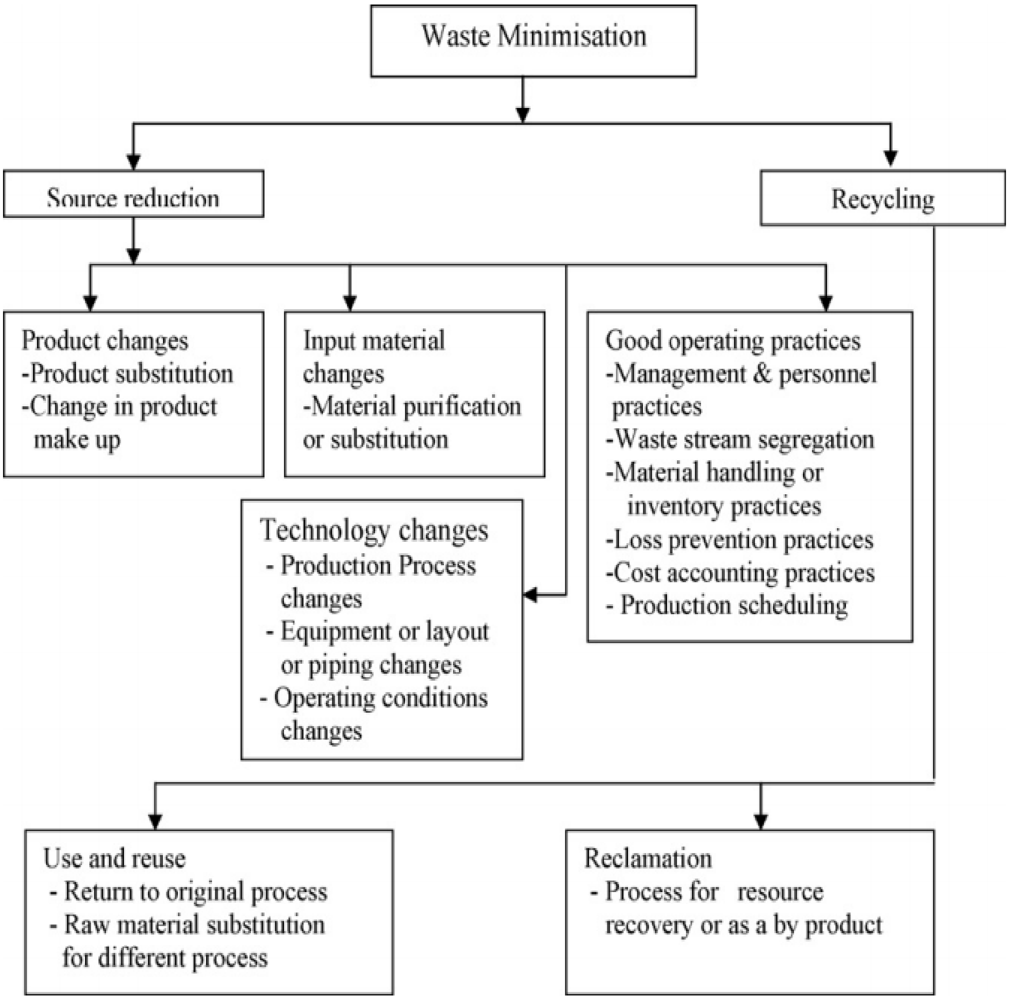
2.3.5 Drywall

Gypsum can be fabricated into drywall, plaster and other specialist boards such as fire protection. Off-cuts, damaged stock, poor design, poor storage and handling and over ordering are the common sources of gypsum drywall waste. Johnston and Mincks (1994) indicate the disposal of gypsum drywall waste could create many problems as it is not accepted in the normal inert construction waste stream. In general, drywall waste is rejected by incineration plant owing to its non-combustible characteristics. Besides, disposal of drywall waste to lined landfill facilities or municipal solid waste landfills are restricted since it can produce leachates.

However, drywall itself is highly recyclable. Tom Napier (2012) suggests that gypsum may be incorporated into new drywall or applied as a soil conditioner. Besides, waste reduction is also a good way to minimize drywall waste. Revised awareness of waste reduction in apprenticeship and training scheme help to utilize waste on the jobsite (Johnston and Mincks, 1994).

2.4 Waste Minimization Practices

Waste minimization can be grouped into three different forms. Recycling, reuse, composting and salvaging material are classified in one category; source reduction, use of recycled material and control of material to lessen final waste is another, and last category includes burning of excess materials in waste-to-energy plants. These practices are shown in Figure 2.3 as below.



(Source from Begum et al., 2006)

Figure 2.3: Waste Minimization Options

2.4.1 Source Reduction

Source reduction is the highest goal in the solid waste management hierarchy as it is generally superior to the recycling and disposal practices from the standpoint of an environmental and economic perspective (Anne Arundel County, 2008). Its importance is underlined by Peng and Scorpio (1997) and Viljoen (2010) where they agreed reduction is the best and most important way to overcome waste problems efficiently. Begum et al. (2006) describes source reduction as an activity with the purpose of reducing or eliminating waste generation at the source within a process.

It simply means to create less waste or otherwise manage the materials so that they will not become wastes to be disposed. This practice includes redesigning products by using fewer materials, reusing products and extending the functional lifespan of products (US Environmental Protection Agency [EPA], 2012). In short, waste can be prevented before it occurs.

There are several source reduction examples provided by Dubuque Metropolitan Area Solid Waste Agency [DMASWA] (n.d.). Adopting standard-size materials in the project design is encouraged as less wastage may occur. Indirectly, it can also eliminate excess labour cost due less cutting required and speed up the whole construction process. Besides, it is advisable to improve the material storage procedures in order to avoid spoilage of materials. Ensuring that every purchased material is being used optimally for its specified purposes and avoid over ordering to minimize waste generated. Less packaging left at the site by requesting suppliers to deliver goods with minimum packaging is also a good practice.

2.4.2 Recycling and Reuse

There is a high potential for recycling and reusing construction wastes since some of its components contain a high resource value. Altuncu and Kasapseckin (2011) agree by pointing out that it is possible to reuse construction waste as a secondary raw material once being duly processed. Recycling involves diverting non-reusable materials from the solid waste stream and using these extracted materials as feedstock for reprocessing into functional products (Unified Facilities Criteria [UFC], 2002). However, only clean material with little contamination will be accepted by recycling companies. Thus, source separation on the jobsite is required. Sometimes, a fee is charged for collecting recyclables, but it is often less than the disposal cost to landfill.

Recycling and reusing construction waste is recommended for adoption where reduction is not feasible. It is economically viable to recycle up to 80-90% of the total amount of construction and demolition waste in most European countries

(Lauritzen, 1998). In Malaysia, a study by Begum et al. (2006) estimates about 73% of the waste materials is reused and recycled. Notwithstanding recycling and reuse is highly beneficial to the community, Peng and Scorpio (1997) support the fact that there is a limitation for implementing recycling of construction materials where an aggressive marketing effort is necessary to create markets and trade the materials with highest possible prices. Significant time and money are therefore spent to ensure continuous material flow. However, this is just a shortsighted view. In fact, recycling and reuse of waste can generate economic benefits by selling waste materials to earn extra income and reduce the amount of waste to be disposed in landfills which the disposal cost is usually higher. Furthermore, proper management of material waste induces higher construction productivity and thus saving time (Skoyles and Skoyles, 1987).

Concept of reuse is emerged since inadequate sources are available to reserve capacity and increasing consumption due to growing population. In general, most items from residential and commercial buildings are reusable, for example, tubs and cabinets, which in a good and resalable condition might be substituted for new products or can be donated to nonprofit groups enabling them to repair homes for low-income families (Tom Napier, 2012). Using materials and supplies from salvage yards or second-hand stores for a project usually saves cost, while at the same time helping to promote markets for those materials (DMASWA, n.d.).

2.5 Merits of Implementing 3-R Practices

Reduction, recycling and reuse of wastes are vital for sustainable management of resources. Benefits of implementing these practices are numerous and varied. By managing the waste wisely, it will increase efficiency along with saving money and resources.

2.5.1 Cost Saving

Reduce, recycle and reuse construction wastes can save money and control costs by decreasing the need to purchase new construction materials and reducing waste disposal fees. Eventually, total project cost is lowered. Cost saving, in turn, may generate profit maximization.

2.5.2 Create Environmental Benefits

3-R practices are environmental-friendly. Cutting the amount of waste sent to landfills can save landfill spaces. Meanwhile, incorporating these proven techniques for waste minimization can save natural resources such as trees and minerals. As a result, negative environmental consequences such as noise, pollution effects of landfill as well as emission and residues from incineration could be eliminated (Hwang and Yeo, 2011).

2.5.3 Enhance Company's Reputation

Increasingly, it becomes common for better resource efficiency to be included as a contractual requirement. The capability to demonstrate a proper waste management could be an extra advantage for the company. Incorporating 3-R practices in waste management policy may improve the company's public image and enhance the impression on clients.

2.5.4 Improved Site Condition

Well managing construction waste may result in a cleaner and safer site. The reusable and recyclable waste materials should be stored separately for subsequent recovery and diversion. If the materials and waste are handled properly, it could lead to a better health and safety as there are likely to be fewer accidents occur. In addition, workers' productivity could be improved (National Specialist Contractors Council [NSCC], 2007).

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

Research is necessary so as to ensure the study to be carried out in more effective way. Carefully organized and controlled research enables researchers to evaluate different theories and approaches, explore ideas, probe several issues and obtain most reliable solutions to solve specific problems. By doing research, the truth which is hidden or which has not been discovered yet can be uncovered.

Researchers must comprehend the methodology besides knowing each research techniques. They should understand the way on how to develop certain indices or tests, how to calculate by using specified formulas and differentiate their applications on the studies. Since problem facing might be different to one another, researchers must be able to consider the logic behind the methods used in the context of research study.

3.2 Types of Research

The classification of research can be determined by its purpose and by methods. Many different ways exist to carry out research but broadly speaking there are two principle approaches, namely quantitative and qualitative. These two research models are generally applicable along with their respective advantages and disadvantages. Hence, many researchers implement a pragmatic approach, simply adopting whichever method is best fitted to answering their research questions and which might even combine both paradigms within the same study (Alzheimer Europe, 2009).

3.2.1 Quantitative Research

Quantitative research is primarily focused on the measurement of quantity where its results are based on numeric analysis and statistics. A sample that closely represents the population will be chosen for examination. This type of research introduces structured questions, where the response options are usually predetermined and large number of respondents being involved. However, it has drawback where the data collected may lack of depth (Henninger, 2009).

3.2.2 Qualitative Research

Qualitative research concerns with phenomena relating to quality or kind. Results are rather in words or graphics and typically only have fewer participants involved. Qualitative methods guarantee quality of survey. An interview and case study are the examples. Basically, it is more toward for exploratory purposes. The research is more open to different interpretations, and thus, it can be criticized that the researchers may have prejudice thoughts (Henninger, 2009). Additionally, regardless of the kind of data gathered, data collection in a qualitative study consumes a great deal of time.

3.3 Data Collection

Data is an essential aspect in every research. It can be displayed in several forms such as figures, images or words. However, data in itself cannot be understood and to acquire information from the data, interpretation is required (Naveen, 2012). Generally, data sources can be classified into primary data and secondary data.

Primary data is the data that is collected first hand from original source. The information has not been interpreted by anyone other than finder himself, and thus, its validity is greater than secondary data. Once primary data is gathered, new information will be added to existing store of social knowledge. Gradually, the finding is made available for reuse by general research community. It is now termed as secondary data (Hox and Boeije, 2005). This data type should be examined to ensure the information is updated to latest form. Secondary data may less valid, but it is still important in research study as getting information from secondary sources is much more easier compared to primary sources. Furthermore, the data is available in a cheaper and quicker manner.

3.3.1 Sources of Primary Data

Primary data is the most current information obtained that fit exactly to research's needs. The process in collecting new data may be time consuming and expensive, however, it can be the most authentic and reliable data source. Questionnaire and interview are the two important primary sources that will be discussed in detail as follow.

3.3.1.1 Questionnaire

This research instrument is commonly adopted in most surveys. It is a written list of questions whereby the questions set must be clear and understandable so as to enable the respondents easy to read and reply precisely. The survey questions can be further categorized into two main types, which are open-ended questions and closed-ended questions. For open-ended questions, respondents are asked to answer each question by their own words. It allows the respondents to express themselves freely, therefore could eliminate the possibility of investigator bias. Nevertheless, analysis would be more difficult. Sometimes, respondents may not be able to express their opinions, hence resulting in failure to obtain useful information. Closed-ended questions are preferable thanks to the ease of counting the frequency of each response. They are easy to analyze since the possible responses have been categorized properly by researcher. However, the information gathered may lack of depth and variety and most probably, investigator bias do exist.

Questionnaire can be administered personally by researcher, sent by email or posted on website. It is a less expensive technique for research. Additionally, it provides uniformity whereby each respondent will receive identical questions to be answered and their responses are normally standardized by using closed-form questions. The researcher, therefore, could interpret various data collected in an easier manner. Since no face-to-face interaction between respondents and interviewer, use of questionnaire could offer greater anonymity. Unfortunately, low response rate is always the problem faced by researcher. In case of the respondents do not understand the questions asked, they may refuse to respond or may answer them incorrectly. Hence, quality of the information will be affected.

3.3.1.2 Interview

Interview is a far more personal type of research compared to questionnaire. It could be personal interview or telephone interview. Personal interviewing generally yields maximum cooperation and lowest refusal rates. It can be an excellent means to gain in-depth information from a person, thus guarantees the quality of data obtained. Interview is very time-consuming and resource intensive. Interviewer, as a part of measurement instrument, should have well trained on how to respond to any unforeseen event. In general, it is the most costly administration mode and requires relatively longer data collection period. By contrast, telephone interviewing is cheaper and quicker. Like face-to-face interview, it also allows personal contact between respondent and interviewer. The problem is telephone survey often has a higher level of refusal where people usually ignore to take part when approached over the telephone. Choosing the ‘best’ time is always difficult and the interviewer should have ready that he may get rejected through telephone interviewing.

The application is not limited where an interview can be used with any population type. It is less likely that a question asked will be misunderstood as the interviewer can explain in more detail until the respondent fully understands the whole question and be able to provide relevant answer that is useful for research purpose. Furthermore, an interviewer can supplement the information from responses with those gained from observation of non-verbal reactions. The drawback is the interview may not have total neutrality towards all responses. Researcher or interviewer bias in the framing of questions and the interpretation of responses exists in most situations.

3.3.2 Sources of Secondary Data

Secondary data is always readily available. It is useful in comparing findings from various studies and different time periods to assess trends, roots and effects of certain issues. Secondary information sources can be divided into published printed or electronic sources.

3.3.2.1 Published Printed Sources

Good examples of sources in a printed form include books, journals, magazines or newspapers. Any topic that related to the research can easily be found on books, either reference books or textbooks. Books can be considered as the most authentic one amongst others. In many cases, journals or periodicals are able to provide latest information which at times books cannot. Content of magazines may not so reliable but still can be effective in collecting certain data. There may also have some specific information or facts can only be obtained from newspapers as in the case of political issues.

3.3.2.2 Published Electronic Sources

Obtaining data through published electronic sources is relatively cheaper and more convenient. It has been seen that much information that is less available in printed form is now available online. E-journals, weblogs, government or semi-government publications are some of the secondary sources which being frequently adopted for researches nowadays. Some online journals are free but some latest one may difficult to retrieve without subscriptions. For those not available, researcher can purchase online to get its full contents. On the other hand, weblogs are also becoming useful in collecting relevant data. They are actually diaries written by many different people where the information contained within is reliable as personal written diaries. Apart from that, there are also numerous government and semi-government organizations that gather data on a regular basis in different areas and publish the results for use by public or other interest groups. Some common examples include economic forecasts and census.

3.4 Data Analysis

A few techniques have been used to analyze the collected data. These include descriptive statistics method and inferential statistics method.

3.4.1 Descriptive Statistics Method

Descriptive statistics is the statistics procedure that used to describe the data. The result obtained by the descriptive statistics method cannot be generalized into larger group. This technique is simple for analysis and easy to understand, it gives brief information on the sample or population. Frequency distribution is an example of descriptive statistics (Question 1 – 9).

3.4.2 Inferential Statistics Method

Inferential statistics method is applied when making any prediction or inference about the population from the results of sample. One of the benefits of inferential statistics is the result of sample can be used to generalize into larger population that the sample represents. One of the examples of inferential statistics is one-tailed one-sample t-test (Question 10 – 13).

3.4.2.1 One-Tailed One-Sample t-Test

A one-tailed one-sample t-test is to test the null hypothesis that a population mean is equal to some hypothetical value (Price & Oswald, 2008). The assumption of t-test is normally distributed in a population and t-test is useful when the sample size is small (e.g. $n \leq 30$). The significant level or alpha is set at 5% for the present research. The t-test formula as follow:

$$t_{observe} = \frac{\bar{x} - \mu}{\frac{SD}{\sqrt{n}}}$$

where:

$\bar{x}$ = sample mean

μ = specified value to be tested – population mean

SD = sample standard deviation

n = sample size

CHAPTER 4

ANALYSIS AND DISCUSSION

4.1 Introduction

Findings and discussion of results obtained from the survey questionnaire and interview will be analyzed in this chapter. Total of 30 sets of questionnaires had been collected successfully from various construction parties. Also, the summaries of interview with two professionals will be prepared accordingly.

4.2 Survey Questionnaire

Numbers of survey questionnaire were received from different building professionals i.e. contractors, developers, engineers and quantity surveyors, who work in Klang Valley or Johor. Their judgments and working experiences in construction field contribute significantly for the purpose of this research.

The survey questionnaire was subdivided into three main parts as Section A - Background Information, Section B - Education and Awareness and Section C - Attitude and Practices. The detailed data analysis and discussion are elaborated as follows:-

4.2.1 Section A - Background Information

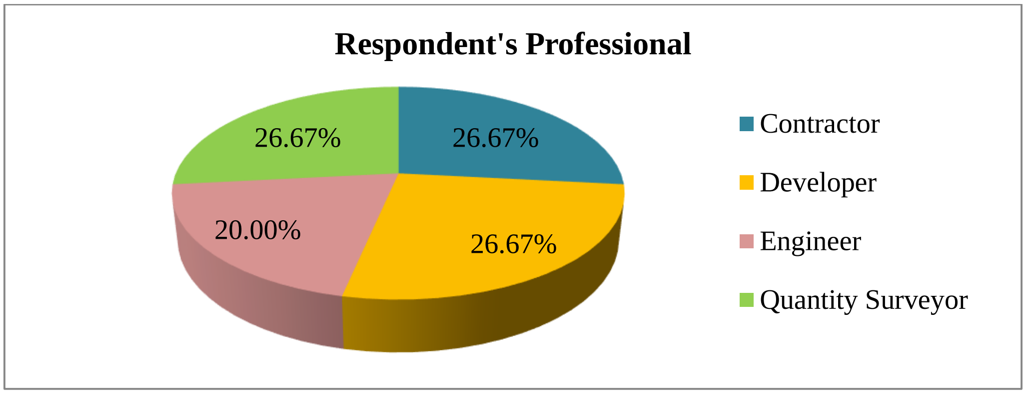


Figure 4.1: Respondent’s Professional

Figure 4.1 above shows the various professions possessed by the respondents in which contractor, developer and quantity surveyor each constitute 8 respondents respectively (26.67%), whilst the remaining 6 or 20% of the respondents are engineer.

Figure 4.2: Years of Working Experience

The chart shown in Figure 4.2 indicates the years of working experience of the respondents in the construction sector. Respondents with less than 1 year working experience form the largest percentage, which is 46.67%, followed by 30% of the respondents who own 1 year to 5 years of working experience in construction field. On the other hand, respondents who have worked in the industry for 6 years to 10 years constitute 13.33% and only 10% of the respondents work more than 10 years in this field.

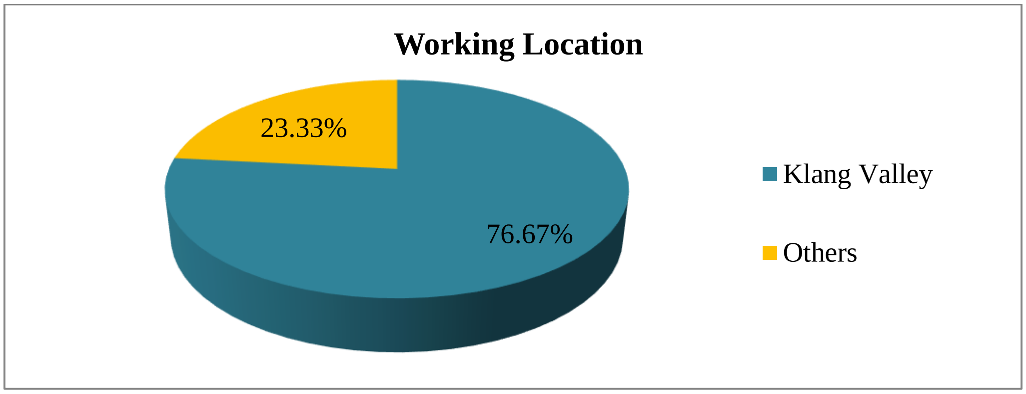


Figure 4.3: Working Location

As illustrated in Figure 4.3, majority of the respondents' working place are located in Klang Valley, which is 76.67%, while 23.33% of the respondents are working in other states, i.e. Johor.

4.2.2 Section B - Education and Awareness

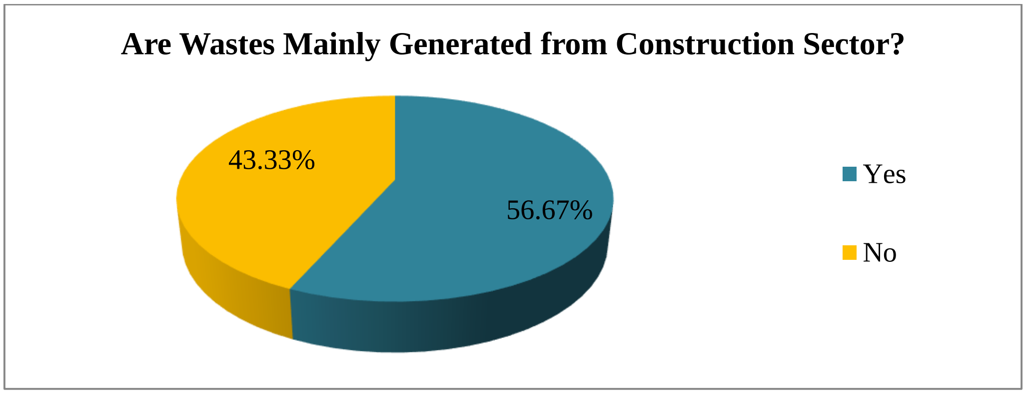


Figure 4.4: Respondent's View on Main Sources of Waste

This question is aimed to obtain the respondents' opinions with regard to whether they agree on the fact that wastes are mainly generated from numerous construction activities. The result shown in Figure 4.4 reveals that 56.67% of the respondents have considered the statement is true. On the other hand, there are 43.33% of the respondents oppose the statement in which they deem that construction sector is not the main source of waste. They argue that household waste is still regarded as the largest portion of waste in the locality.

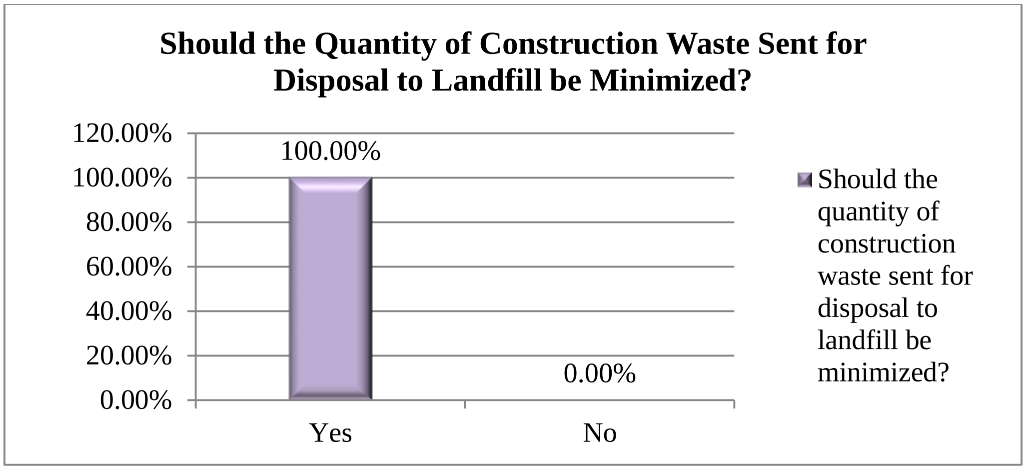


Figure 4.5: Respondent’s View on Construction Waste Disposal Method

This question is aimed to find out whether the respondents agree on the fact that construction waste sent for disposal to landfill should be minimized. The graph in Figure 4.5 clearly indicates that all the respondents have reached a consensus on this issue. They consider this disposal method is not efficient as the landfill spaces in Malaysia are scarce. If this situation continues to happen, it would risk to the strategic use of landfills and probably cause harm to the environment.

Figure 4.6: Respondent’s Support Level on the Principle of Waste Minimization

This question is aimed to discover whether the respondents support the principle of waste minimization. With reference to the Figure 4.6, all the respondents declare that they are strongly supporting the principle. They are aware of the negative impacts brought by the waste problem, thus believe that implementation of 3-R practices could probably ameliorate the circumstances.

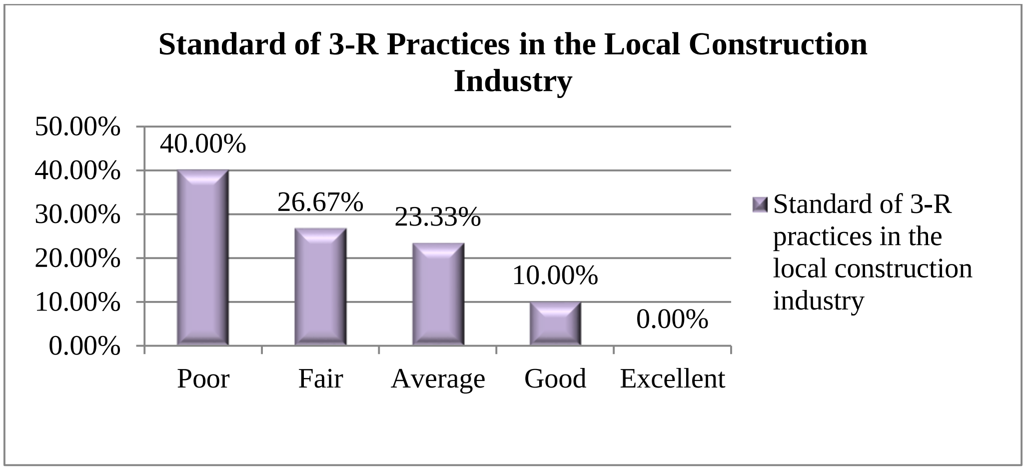


Figure 4.7: Standard of 3-R Practices in the Local Construction Industry

As referred to Figure 4.7, there are 40% of the respondents which is 12 of them have voted “poor” as the standard for 3-R practices in the local industry. Following by 8 or 26.67% respondents have the opinions that the implementation of 3-R practices in this field is “fair” while 7 or 23.33% respondents evaluate “average” as the standard. Only 3 respondents (10%) grade “good” for the standard of 3-R practices in the local construction sector, and none of them consider the practices are doing excellent in the industry.

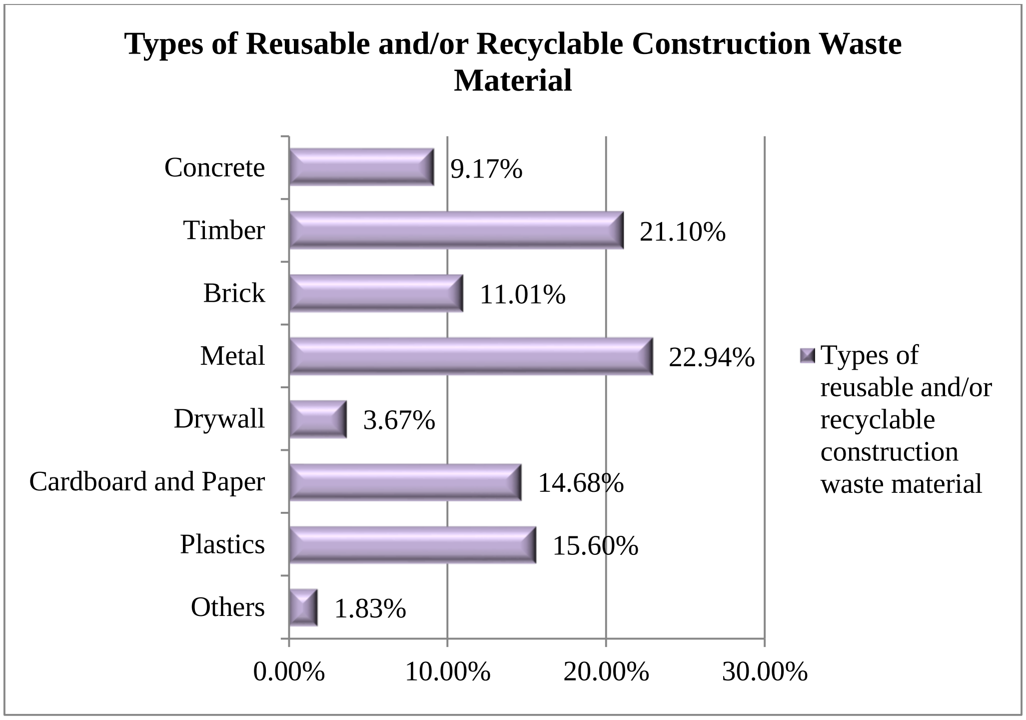


Figure 4.8: Percentage of Different Types of Reusable and/or Recyclable Construction Waste Material

Figure 4.8 above illustrates the percentage of various kinds of construction waste material that the respondents regard as reusable and/or recyclable. Most respondents allocate metal (22.94%) as the major type of construction waste material that can undergo reusing and/or recycling processes. Timber is placed after metal, which it contributes about 21.10% and next followed by plastics (15.60%), cardboard and paper (14.68%) and brick (11.01%). Those waste materials that constitute below ten percent include concrete (9.17%), drywall (3.67%) and others (1.83%). In Chapter 2, concrete is having the greatest amount of reused and recycled construction waste material on the building site (refer to Table 2.4)**.** However, the result gathered from the construction industry shows discrepancy as most respondents have no idea on whether concrete can be reused and/or recycled. They tend to choose the common reusable and recyclable materials like metal and timber when answering this question.

4.2.3 Section C – Attitude and Practices

The survey result shown in Table 4.1 below reveals that the use of durable, low maintenance materials, involved in waste separation and sorting on-site during construction as well as procure raw materials that are just sufficient as needed are the three most effective practices that can contribute to waste minimization. However, one of the practices is deemed as not effective as for waste minimization effort ($\mathbf{t}_{critical}$ > $\mathbf{t}_{observe}$, H_o accepted). There is 95% confidence on the construction parties to disagree that by including waste minimization and recycling performance clauses in the contract could aid in minimizing waste.

Table 4.1: Analysis Result for Level of Effectiveness Among the Waste Minimization Practices

		$H_0 : \mu \leq 3$, $H_1 : \mu > 3$ $\alpha = 0.05$							
Variable (v)	**Waste Minimization Practices**	**Mean (μ)**	**Standard Deviation (σ)**	**Degree of Freedom (n-1)**	$t_{observe}$	$t_{critical}$ ($t_{.05,29}$)	**Result**		**Rank**
1	Encourage designers or clients to use standard product dimensions	3.7000	0.8769	29	4.3723	1.699	1.699<4.3723	Reject H_0	4
2	Attend relevant seminars or training programmes	3.5333	1.0080	29	2.8980	1.699	1.699<2.898	Reject H_0	5
3	Include waste minimization and recycling performance clauses in the contract	3.2333	1.0400	29	1.2289	1.699	1.699>1.2289	Accept H_0	8
4	Procure raw materials that are just sufficient as needed	3.8000	0.8867	29	4.9418	1.699	1.699<4.9418	Reject H_0	3
5	Exchange waste with others or sell waste to others	3.3667	0.9643	29	2.0827	1.699	1.699<2.0827	Reject H_0	6
6	Involved in waste separation and sorting on-site during construction	3.9000	0.9948	29	4.9552	1.699	1.699<4.9552	Reject H_0	2
7	Use of durable, low maintenance materials	3.9667	0.9994	29	5.2977	1.699	1.699<5.2977	Reject H_0	1
8	Return over-ordered materials	3.3667	0.9994	29	2.0095	1.699	1.699<2.0095	Reject H_0	6

Meanwhile, the survey result displayed in Table 4.2 also demonstrates that the use of durable, low maintenance materials is most frequently practiced in the Malaysian construction industry. Return over-ordered materials and encourage designers or clients to use standard product dimensions are both ranked as the second and third most practiced activities in the industry. According to the data obtained, exchange waste with others or sell waste to others is perceived as the least practiced conduct among the construction parties. It is worth noting that all practices are having H_o being accepted ($\mathbf{t}_{critical} > \mathbf{t}_{observe}$). This means that the construction parties seldom, or even never, involve in practicing those activities that they deem would be very effective in minimizing waste. The sole concerns for them are time and cost saving by which any practices that may involve with increasing cost or requires longer time spent and effort would not be paid full attention on. This scenario directly reflects the local business culture is dominated by seeking short-term profits among the parties in the Malaysian construction field (Begum et al., 2006).

Table 4.2: Analysis Result for Level of Frequency Among the Waste Minimization Practices

		$H_0 : \mu \leq 3$, $H_1 : \mu > 3$ $\alpha = 0.05$							
Variable (v)	**Waste Minimization Practices**	**Mean (μ)**	**Standard Deviation (σ)**	**Degree of Freedom (n-1)**	$t_{observe}$	$t_{critical}$ ($t_{.05,29}$)	**Result**		**Rank**
1	Encourage designers or clients to use standard product dimensions	2.8333	0.9855	29	-0.9263	1.699	1.699>-0.9263	Accept H_0	3
2	Attend relevant seminars or training programmes	2.6000	0.9322	29	-2.3503	1.699	1.699>-2.3503	Accept H_0	5
3	Include waste minimization and recycling performance clauses in the contract	2.0333	0.9994	29	-5.2977	1.699	1.699>-5.2977	Accept H_0	7
4	Procure raw materials that are just sufficient as needed	2.8000	1.0306	29	-1.0630	1.699	1.699>-1.063	Accept H_0	4
5	Exchange waste with others or sell waste to others	2.0000	1.0828	29	-5.0585	1.699	1.699>-5.0585	Accept H_0	8
6	Involved in waste separation and sorting on-site during construction	2.4333	1.0063	29	-3.0843	1.699	1.699>-3.0844	Accept H_0	6
7	Use of durable, low maintenance materials	3.0000	0.9826	29	0.0000	1.699	1.699>0.0000	Accept H_0	1
8	Return over-ordered materials	2.9667	1.3767	29	-0.1326	1.699	1.699>-0.1327	Accept H_0	2

Five waste minimization barriers are listed in Table 4.3. Based on the result gathered, lack of possibilities for utilizing waste cannot be regarded as one of the obstacles ($\mathbf{t}_{critical}$ > $\mathbf{t}_{observe}$, H_o accepted). Some of the respondents claimed that there are multiple ways to make use of the waste. For instance, the timber waste which is produced mainly from the formwork can be reused as a pallet for placing building materials. Hence, the remaining four barriers which are significant for further analysis embrace lack of legislation, insufficient environmental awareness and concern, lack of client's interest and lack of specialized trades persons and labourers.

Table 4.3: Analysis Result for the Waste Minimization Barriers

		$H_0 : \mu \leq 3$, $H_1 : \mu > 3$ $\alpha = 0.05$						
Variable (v)	**Waste Minimization Barriers**	**Mean (μ)**	**Standard Deviation (σ)**	**Degree of Freedom (n-1)**	$t_{observe}$	$t_{critical}$ ($t_{.05,29}$)	**Result**	
1	Lack of legislation (absence of penalties)	3.5000	0.7768	29	3.5254	1.699	1.699<3.5255	Reject H_0
2	Insufficient environmental awareness and concern	4.1667	0.7915	29	8.0736	1.699	1.699<8.0737	Reject H_0
3	Lack of client's interest	3.5667	0.8584	29	3.6159	1.699	1.699<3.616	Reject H_0
4	Lack of specialized trades persons and labourers	3.7000	0.9154	29	4.1885	1.699	1.699<4.1885	Reject H_0
5	Lack of possibilities for utilizing waste	3.3333	1.0933	29	1.6699	1.699	1.699>1.6699	Accept H_0

Table 4.4: Ranking of Waste Minimization Barriers among Contractor, Developer, Engineer and Quantity Surveyor

Waste Minimization Barriers	Contractor (n=8)		Developer (n=8)		Engineer (n=6)		Quantity Surveyor (n=8)	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Lack of legislation (absence of penalties)	3.625	4	3.500	3	3.333	2	3.500	4
Insufficient environmental awareness and concern	4.250	1	4.500	1	3.500	1	4.250	1
Lack of client's interest	3.750	3	3.500	3	3.333	2	3.625	3
Lack of specialized trades persons and labourers	3.875	2	3.625	2	3.167	4	4.000	2

As indicated in Table 4.4, insufficient environmental awareness and concern occupied the most significant position as a waste minimization barrier. These may include organizational or individual reluctance to change, lack of commitment and responsibility as well as poor internal communication. Most people do not see themselves as an active performer in the process albeit they know that the condition of the environment should be improved. They tend to assume there would be somebody else like scientists or environmental organizations to handle those environmental issues.

Besides, contractor, developer and quantity surveyor have ranked lack of specialized trades persons and labourers as their second significant barrier whilst engineer has located this element at fourth place. In the view of engineer, lack of legislation and lack of client's interest are more influencing. They claimed that their practices have been restricted owing to the requirements of customers as most customers refuse to invest their money in waste minimization activities. They have no choice but to comply with the clients' needs or otherwise, they may lose the business thereafter. Also, lack of legislation is another barrier by which the legislative bodies should constantly enforce their environmental regulations by imposing penalties or fines to those who have breached the rules.

The data tabulated in Table 4.5 implies that create job opportunities is not treated as an advantage of implementing 3-R practices ($\mathbf{t}_{critical} > \mathbf{t}_{observe}$, H_o accepted). The result only accept cost saving, create environmental benefits, enhance company's reputation, improved site condition and stimulate development of greener technologies as the proper elements for further analysis.

Table 4.5: Analysis Result for the Advantages of Implementing 3-R Practices

		$H_0 : \mu \leq 3$, $H_1 : \mu > 3$ $\alpha = 0.05$						
Variable (v)	**Advantages**	**Mean (μ)**	**Standard Deviation (σ)**	**Degree of Freedom (n-1)**	**$t_{observe}$**	**$t_{critical}$ ($t_{.05,29}$)**	**Result**	
1	Cost Saving	3.3333	1.0283	29	1.7754	1.699	1.699<1.7755	Reject H_0
2	Create Environmental Benefits	4.1667	0.8743	29	7.3090	1.699	1.699<7.309	Reject H_0
3	Enhance Company's Reputation	3.7000	0.8769	29	4.3723	1.699	1.699<4.3723	Reject H_0
4	Improved Site Condition	3.7000	1.1188	29	3.4269	1.699	1.699<3.427	Reject H_0
5	Create Job Opportunities	3.0667	0.9072	29	0.4025	1.699	1.699>0.4026	Accept H_0
6	Stimulate Development of Greener Technologies	3.9667	0.9643	29	5.4906	1.699	1.699<5.4907	Reject H_0

Table 4.6: Ranking of Advantages of Implementing 3-R Practices among Contractor, Developer, Engineer and Quantity Surveyor

Advantages	Contractor (n=8)		Developer (n=8)		Engineer (n=6)		Quantity Surveyor (n=8)	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Cost Saving	3.000	5	3.375	4	3.000	5	3.875	3
Create Environmental Benefits	4.375	1	4.125	1	3.833	3	4.250	1
Enhance Company's Reputation	3.625	4	3.750	3	4.167	1	3.375	5
Improved Site Condition	3.875	3	3.250	5	4.000	2	3.750	4
Stimulate Development of Greener Technologies	4.000	2	4.000	2	3.667	4	4.125	2

As shown in Table 4.6, contractor, developer and quantity surveyor have placed create environmental benefits and stimulate development of greener technologies at the first and second position. Conversely, engineer ranked these advantages at the third and fourth position. Unquestionably, exercising 3-R practices can greatly reduce waste quantity and environmental harm. By reducing transportation of waste to be disposed of, it is thus resulting in lesser vehicle emission pollution. According to the engineer, enhance company's reputation should be ranked at the top. The environmental profile of an organization is essential on its overall reputation. If the company has regularly executed waste minimization practices, it provides an impressive image to the public. Some clients would put these companies as their priorities for selection. However, this advantage is not so appreciated by quantity surveyors and hence it was placed at their fifth position.

The result shows that the developer has ranked improved site condition at the last position. Both contractor and engineer have opined that implementation of 3-R practices seldom bring cost saving for them. This statement is agreed by one of the interviewees, Mr. William Goh. He stated that it would probably cost more to the contractors if they are required to exercise 3-R practices on site as the labourers have to spend their normal working time in doing these and usually it takes longer time to finish. Consequently, their construction works being disrupted, causing project cannot be completed on time. At the end, they need to employ extra labor to execute the works or otherwise, they have to pay damages to client.

4.3 Interview

Face-to-face interviews with two professionals who have 10 years and above working experiences in their construction company were done in order to obtain a better understanding on 3-R practices in local construction area.

4.3.1 Interview with Construction Company Director

On 12th February 2014, first interview was conducted with Mr. William Goh, Director of Barisan Performa Sdn. Bhd. who has working experience in the construction industry for over 17 years. Below is the summary of interview made.

The interviewee declared that 3-R practices in the Malaysian construction field are not so prevalent. Only a very small portion of companies have involved in exercising those practices in their projects but normally not every single project due to certain issues such as budget problem or client’s interest.

He pointed out that concrete, bricks and timbers are the three main solid wastes generated in most construction and demolition (C&D) projects. Those wastes could either be reused or recycled. However, majority of people refuse to recycle concrete waste due to their misconception and ignorance of its possibilities for application. In fact, most concrete could be crushed and reused as aggregate for use in ready-mix concrete or could be recycled through the cement manufacturing process as an alternative raw material to fabricate clinker. These recovered concrete is highly recommended for application in road sub-base and civil engineering projects. Recycling concrete reduces waste landfill as well as natural resource exploitation. Mr. William opined that the only trouble is it will cause a minor impact on reduction of greenhouse gas emissions because most emissions take place while cement is made and unfortunately, cement is totally not recyclable. The cement waste requires extra money for its disposal and it would be a big overhead (unexpected cost) for the company.

According to Mr. William, the reinforcement bars could be extracted from those unwanted concrete after demolition and sent to the steel yard for recycling. Normally, legal-operated steel yard would not be their first choice as the yard would only accept bulk quantity of bars for recycling. Therefore, most of them would rather send all those recyclable bars to illegal-operated steel yards for further processing. Also, the premix road waste could be employed to build platform in car park area since it is relatively inexpensive. He indicated that although waste lubricating oil from construction vehicle and machine is hazardous, there are several applications available for reusing purposes. Varnishing of lubricant waste on reinforced concrete retaining wall could minimize the water penetration into the wall. Besides, timber formwork painted with lubricant waste would enhance its performance and maintenance. The surfaces become smoother and non-sticky and thus easy to dismantle.

From design to completion stage, waste could be generated due to factors such as inefficient design work, inaccurate quantity take-off, design changes, errors and mistakes in material estimating and ordering, poor logistics and storage, carelessness of labour and rework owing to defective or low quality of work. Skillful and experienced contractor plays a significant role in eliminating or minimizing wastage generated by these causes. To mitigate waste problem, Mr. William stated proper supervision and management in every single stage of construction is very important. Before proceed to material procurement, contractors should have done their estimation accurately. Building materials should be ordered adequately according to operating team performance. Avoid any surplus ordering as there will be higher possibility to create unnecessary waste on site.

The interviewee averred that local construction industry is still lagging behind in advancing 3-R practices mainly because of the practitioners consider that construction waste problem is not severe in the country yet. They refuse to practice those activities which they deemed would be more likely to waste their time and money. Furthermore, there is no strict monitoring on controlling of construction and demolition waste by authorities which leads to poor attention given by the firms in handling solid wastes. According to Mr. William, some unscrupulous contractors would even dump bulky construction wastes to areas where transmission line towers located as those areas are usually large in size and lack of stringent administration by government officials. They intended to maximize profit by avoiding payment charge to the legal landfill.

In Mr. William's opinion, Taiwan is one of the best countries who succeed in handling wastes. In the past, Taiwan had confronted waste crisis owing to scarce of resources and lands to expand its landfill capacity. As a result, the public tends to shift their material use pattern to become more sustainable for Zero Waste. The waste management policies in Taiwan have been evolved with transformation of society which begins with open dumping, sanitary landfills, striding over incineration, recycling and recovery, source reduction and now progressively towards Zero Waste. No doubt that Taiwan is a good model that leading towards establishment of green environment. People of Taiwan possess deep opposition to the method of burning waste and show a great enthusiasm to participate in waste prevention and recycling practices. They are aware of the importance of sustainability through communication with governmental and non-governmental organizations.

Mr. William underlined that commitment of the working team is essential to a successful waste minimization practice. Providing training to everyone working on the site about the reuse and recycling procedures is necessary. In addition, by having regular meetings with the team, it is possible to discover whether they have any problems or suggestions concerning waste handling on site. Moreover, positive communication and employee recognition are both important to ensure a long-term success of waste minimization efforts. No doubt that government owns a critical role in advocating 3-R practices where the government should enforce the relevant provisions by imposing penalty or fines on those who fail to handle construction waste properly.

4.3.2 Interview with Contract Manager

On 12th February 2014, second interview was conducted with Mr. Vong Wai Voon, who works as a Contract Manager in Barisan Performa Sdn. Bhd. for more than 10 years. The summary of interview prepared as below.

According to Mr. Vong, the running of 3-R practices in local construction field is poor. Majority of small-sized and medium-sized firms would not have the capability in doing these activities, whereas big companies have less interest to get involved even though they possesses greater ability to put into practice.

He ranked timber formwork as the most wasteful material during construction operation on site but also stated that its impact on the environment is less harmful as it could be sold to scrap dealers at the end of the project which in turn utilize them for minor jobs such as temporary formwork for concrete or fencing around sites.

A good planning and design are vital to mitigate waste problem on construction site. Mr. Vong suggested planning the timing of purchases so that the material delivery is just-in-time for the required construction stage. Besides, try to avert keeping materials in site storage for too long period as this could tie up funds and higher possibility to occur damage, spoilage and pilfering. Indeed, large volumes of waste are produced owing to onsite cutting of materials to fit dimensional constraints of a project design. By taking account of the wastage at an early stage in the process, design could be optimized for resource efficiency.

Mr. Vong revealed that landfill is more preferred means of disposal than incinerator in Malaysia because of the demographic behavior. It is simpler and cheaper to engage than incinerator which the later requires involvement of technological experts. Nonetheless, in current situation, the local authorities are facing constrains in scarce of landfill for final disposal. Additionally, poorly managed landfills would cause serious environmental threats such as stench, water contamination, air pollution, public nuisance and potential health hazards. The interviewee claimed that solely depending on the disposal scheme to tackle the solid waste problem is not a permanent cure and thus, 3-R practices are now becoming more important to deal with the pressing waste crisis.

One of the challenges that limit the reduction, reusing and recycling of solid wastes in the industry is the lack of awareness among local contractors and labor in relation to waste management techniques and approach. Construction firms, therefore, should take the responsibility to provide sufficient training to the unskilled labor about proper procedure to minimize building waste. In fact, this is an important step towards waste reduction at source. Apart from that, the local recycling industry is not well-established yet where there is still lack of sufficient marketing and advertising available. Other than the common markets such as salvage, metal and cardboard recycling are well known, however, it is difficult to obtain information on what kind of services are also available in the industry, for example, concrete crushing. This lack of self promotion could be one of the factors that further contribute to the lack of knowledge of potential services to the construction field.

The interviewee also agreed that regular training should be provided for the staffs to update on matters concerning construction waste and possible ways to minimize it. If they have the relevant knowledge and awareness, they will know how to handle the waste problem more efficiently, thus possibility of waste generated on site throughout the construction process would be reduced to a minimum. In addition, specifying the exact requirements to the suppliers to avoid over-packaging goods or unnecessary packaging is one of the most effective ways to avoid waste. He also recommended that the environmentally improved materials, for instance, those made from recycled content, should be incorporated in building work wherever possible. Take initiative in supporting 3-R practices could create a greener environment in the country.

Undoubtedly, if solid wastes are not well managed, there are possible negative impacts to occur. Mr. Vong indicated that the stacking of excess material waste on site would affect the mobility of construction labor during working. Also, it may result in smell nuisance, groundwater contamination, air pollution and even become a breeding ground for disease-causing vectors. In most cases, the contractors are unwilling to implement 3-R practices in their projects because they believe these doings would increase the project cost. In fact, an effective waste management plan would generate a considerable economics savings by way of reducing waste disposal cost up to more than 20% through diversion of waste from landfill.

In Mr. Vong's opinion, 3-R practices have been implemented gradually in other countries and it's time for the Malaysian construction firms to start practicing these activities not only in the upcoming construction projects, but also including on their daily routines. He claimed that his company had paid transportation cost for waste handling in every project they carried out. However, he had no idea on how the legal transporters manage their waste. He pointed out that this actually was a current issue faced by most construction firms as they did not show any concern on further process once they paid legally and thought they had already fulfilled their responsibilities. Mr. Vong affirmed that no country could perfectly reduce all waste, however, if everyone takes serious on this matter, it could lead to a cleaner and better place to stay.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

Summary of survey findings and conclusion of the study will be discussed in detail. By the end of this chapter, some recommendations will also be provided for further research purpose.

5.2 Summary of Survey Findings

Summary of survey findings is prepared as follows:-

a. Respondent's professional
   - There is an even distribution of samples among contractor (26.67%), developer (26.67%) and quantity surveyor (26.67%). The remaining 20% works as engineer.

b. Years of working experience
   - Majority of the respondents have worked in the industry for less than 1 year (46.67%).

c. Working location
    - More than half of the samples are based in Klang Valley (76.67%). Other state includes Johor only (23.33%).

d. Respondent's view on main sources of waste
    - Numbers of respondent who agree that wastes are largely produced from the construction sector (56.67%) are slightly more than those who disagree (43.33%).

e. Respondent's view on construction waste disposal method
    - None of the respondents disagree that quantity of construction waste sent for disposal to landfill should be minimized (100%).

f. Respondent's support level on the principle of waste minimization
    - All of the respondents are said to be fully supported the waste minimization principle (100%).

g. Standard of 3-R practices in the local construction industry
    - Poor standard is ranked by most respondents (40%) whilst the positive comments from the respondents only consist of 10%.

h. Percentage of different types of reusable and/or recyclable construction waste material
    - Metal (22.94%), timber (21.10%) and plastics (15.60%) are classified as the three major types of construction waste materials that the respondents think can be reused and/or recycled. Besides, a respondent gave an opinion that grey water is reusable and recyclable waste.

i. Level of effectiveness among the waste minimization practices
    - Respondents have ranked the use of durable, low maintenance materials as the most effective practice that can contribute to waste minimization. Meanwhile, they consider include waste minimization

and recycling performance clauses in the contract is not an effective way to settle waste problem.

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j. Level of frequency among the waste minimization practices
   - The use of durable, low maintenance materials is ranked as the most frequently practiced conduct whereas exchange waste with others or sell waste to others is perceived as the least practiced conduct among the respondents.

k. Waste minimization barriers
   - Lack of possibilities for utilizing waste is rejected as one of the barriers in waste minimization practice. All parties have selected insufficient environmental awareness and concern as the major obstacle.

l. Advantages of implementing 3-R practices
   - Respondents do not accept creating job opportunities as one of the advantages. All parties have ranked create environmental benefits at the top, except engineers who set enhance company's reputation as their first ranking.

5.3 Conclusion

Four objectives are laid down in the study, which are to identify waste problem in the Malaysian construction field, to investigate reusable and recyclable construction waste materials on site, to identify degree of 3-R practices in local construction and lastly to explore the advantages of 3-R practices.

As referred to several published researches done by other researchers, it can be concluded that the construction waste has contributed a significant amount to the total solid waste generated in the country. This declaration is echoed in the findings of the study by Hassan et al. (1998) which found that construction sector has been regarded as the second main source of waste in Malaysia. Undoubtedly, this scenario is becoming a pressing issue that should be paid attention on. In order to mitigate the seriousness of waste problem, the “3-R”- reduce, recycling and reuse should be actioned all the time.

The survey results disclose that majority of the respondents know metal waste can be reused and/or recycled. Next would be timber, plastics, cardboard and paper with brick in sequence. According to the findings done by Begum et al. (2006), concrete and aggregate possess the highest rank in amount of waste generated and at the same time, the largest quantity of waste that are reused and recycled. However, the result shows only a small proportion of people realize concrete is recyclable.

On an overall basis, it can be said that the concept of 3-R practices is still frail among the local construction parties. Although they realize how good those practices that can bring towards the environment are, they refuse to perform in real life. This is a common situation faced nowadays. The environmental awareness will only start to develop once people notice that something unfavorable are emerging to the surroundings and usually at the end, those effects cannot be rectified easily.

A variety of advantages are associated with 3-R practices such as financial and environmental benefits. However, in some cases, reuse and recycling may not always be financially feasible. Therefore, other consideration like environmental benefits should be taken into account. Practicing 3-R enables the targets of environmental standard to be met easily. In addition, environmental impact of waste can be lessened effectively hence creating a greener atmosphere.

5.4 Recommendation

Throughout the whole preparation of this research, there are some difficulties encountered. Firstly, the questionnaire responses are mainly collected from Klang Valley. Only 7 responses have been received from Johor state and no more.

Secondly, only a total of 30 responses have been collected successfully. Due to its small sample size, some of the analysis tests cannot be carried out as the requirement for the sample size is larger. Lastly, most of the responses are obtained from those who have working experience of not more than 1 year. The quality may be affected as the more extensive of working experience in the construction sector which the respondents possess, the reliability of opinions of the respondents are further enhancing. For these reasons, the result obtained cannot be regarded as very accurate since it may not reflect the fact.

For further research purpose, it is recommended to conduct a real case study on construction site. The reason is that it will enable a better understanding with regard to the construction waste issue and can have an observation on how 3-R practices are being carried out on actual site. The information gathered would therefore be more accurately reflecting the situation in the locality.

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APPENDICES

APPENDIX A: Sample of Survey Questionnaires

APPENDIX B: Returned Questionnaires

Appendix C: *t* Table

APPENDIX D: Sample of Interview Questionnaire

APPENDIX E: Respondent Profile

APPENDIX F: Record of Supervision / Meeting