WASTE RECYCLING IN THE 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

I certify that this project report entitled **"WASTE RECYCLING IN THE CONSTRUCTION INDUSTRY"** was prepared by **STELLA YAP PEI SHAN** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of Science (Hons.) Quantity Surveying at Universiti Tunku Abdul Rahman.

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Specially dedicated to
my beloved grandmother, mother and father

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ABSTRACT

Construction waste and pollution is no longer a new issue to construction industry. Rapid growth of construction activities generates construction waste and is fast becoming a serious environmental problem nowadays. Improper waste management systems often cause the pollution of air, land and water, and contribute to resource consumption. Other than using natural resources more wisely, it is very important to improve waste management systems in order to improve the cleanliness, and environmental health. Recycling techniques and reducing waste methods are getting increasingly important. Most of the construction and demolition waste in our country are not recycled but end up in dumping and landfill which can cause serious environmental impacts and the need to build more landfills in the future. This research was carried out to identify the construction materials that can be recycled, the methods used to dispose of the construction waste and the advantages of recycling the construction waste. From the research, the construction materials which are commonly recycled are asphalt, brick/blocks, cardboard, concrete, drywall/wallboard, glass, masonry/mortar, metals, and wood/timber. The methods used to dispose of the construction waste are recycling, reuse, landfill, dumping, incineration plant and open air burning. The advantages of recycling the construction waste are to avoid trash collection and disposal fees, improve organization's public image, make new products from old materials, improve the market for recycled content products, helps meet local and state waste reduction goals, increase profit, increase landfill life and to reduce environmental impacts.

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CHAPTER 1

INTRODUCTION

1.1 Background

The construction industry produced a whole variety of waste, the amount and type of which depends on factors, such as the stage of construction, type of construction work and practices on site. Construction and demolition waste is the waste materials generated during the construction, renovation and demolition of the buildings, roads and structures which often contain bulky, heavy materials, and salvaged building components and contribute significantly to the polluted environment. The construction waste is basically generated by the wide range of projects such as residential area, commercial building, office and shopping complex.

The construction, management, use, change and demolition of the built environment can damage the environment to a substantial extent (Nazirah, 2009). Since the construction projects are increasing, there is a large amount of waste produced from the construction activities. This has been a serious problem related to environmental in many large cities of the world. If the waste in the construction industry do not handled effectively, it may cause serious impact on the environment.

Environment issue is getting more attention and the awareness of environment in Malaysia is growing. It is very important to improve energy efficiency, to further develop waste management and recycle. Construction waste recycling can be defined as the separation and recycling of recoverable waste materials generated during construction and remodelling. Packaging, new material

scraps and old materials and debris all constitute potentially recoverable materials. In renovation, appliances, masonry materials, doors and windows are recyclable. In addition to energy savings, recycling also keeps materials out of landfills (Today's Recycling Solutions, 2008).

1.2 Context of the Research

In Malaysia, the construction development projects are increasing as the government is taking the initiative towards making Malaysia a developed country by 2020. Construction is one of the important sectors which can influence the economy of our country. This sector creates many work opportunities to people and brings benefit to the parties who are involved in the process of construction such as contractors, consultants and architects. However, this can only be realized if the construction process is managed effectively.

The construction sector, while being one of the most important contributors to overall socio-economic development in every country is, on the one hand, a major consumer of natural non-renewable resources and, on the other, a significant polluter of the environment Thus, environmental awareness and the management of construction waste are necessary and require immediate attention in order to face the increase of waste generation and disposal of the waste.

The management of construction waste is a problem suffered worldwide (Adam, 2004). Malaysia, like most of the developing countries, is facing an increase in the generation and disposal of waste. Waste management is becoming a severe problem as rapid construction industry growth in order to achieve higher economic development. The big increase of construction waste due to the extensive building and infrastructure development projects have led to larger quantities of waste materials requiring management.

Waste management is now no longer an option but a necessity. Recycling is a simple concept and one of the best options to convert the waste material into

recycled contents. Recycling has almost drawn the universal acceptance as a form of waste disposal but yet our national domestic recycling rate still hovers at around a mere five per cent (Chandravathani, 2006).

Wastages affect not only our environment but also incur extra costs to the contractors and developers. Many countries especially the developed countries have started to aggressively recycle the construction materials due to its many benefits. Recycling can benefit the bottom line of a construction business, and benefit the environment. In addition to conserving raw materials, recycling conserves energy and water, and reduces the production of greenhouse emissions and other pollutants. On and off the job site, recycling is one of the most significant commitments that can be made to sustainable building (Recycling Construction and Demolition Waste, 2005).

1.3 Problem Statement

Nowadays, construction industry is growing rapidly especially in the developing country. Construction waste is becoming a serious environmental problem in Malaysia and it is obvious that construction is a large portion of the waste stream.

Most of the construction waste goes to the landfill which may increase the burden on landfill loading and operation. New landfills can be difficult to site, and old ones are filling up and closing each year. Given these challenges, many in the construction industry have begun to consider alternative solutions to the disposal of construction and demolition debris such as recycling and reuse (Kim, 2011).

The large number of waste generated from construction may lead to the pollution of environment. Waste from sources such as solvents or chemically treated wood can result in soil and water pollution. Pollutants that are released or discharged from the disposal sites could contaminate groundwater system, flora and fauna which will eventually cause direct and indirect impact to human's life (Mahmood, 2000).

Most of the construction companies concentrate in gaining maximum profit and therefore failing to manage the construction waste properly. Reducing, reusing and recycling appear to be profitable alternatives to manage the construction waste. Waste management should be implemented in the construction industry. It is important that the construction companies should be trained to have proper waste management which includes implementation of recycling practices and aware of environmental pollution.

1.4 Rationale of the Research

The main reason of this research is to improve the knowledge of the local construction company and give better environment awareness and understanding of the advantages of recycling the construction waste generated to the construction developments in our country. Other than improve and elevate the level of environment awareness, the contractors could be trained to have proper and good planning of waste management and understand the environmental importance of recycling. All of the construction waste, including solid debris and wastewater, generated during construction activities shall be disposed of in accordance with applicable regulations.

In addition, this study research is also to convince all the parties who are involved in the construction industry that recycling is the best and economically viable option to dispose the construction waste. With recycling the waste, the utilization of new raw materials, energy consumption, air pollution by incinerators, and water pollution by landfills is reduced.

1.5 Aim and Objectives

The aim of this study is to investigate the waste recycling in the construction industry. In order to achieve the aim of the study, the objectives are as follow:

a) To identify the construction materials that can be recycled.
b) To identify the methods used to dispose of the construction waste in Malaysia.
c) To identify the advantages of recycling the construction waste.

1.6 Scope and Limitation of Study

The scope of the study focuses on construction waste recycling in Klang Valley. This study intends to collect and analyze the construction waste generated which could be recycled and identified the methods that are used to dispose of the construction waste.

There are several of limitations in this study. First of all, the research study is only being conducted at certain areas. The questionnaire survey is only intent to cover construction parties allocated in Klang Valley only. As a result, the feedback does not clearly represent the waste management practices of the whole construction industry in Malaysia. It may reflect only a minority of the industry.

The second limitation is the time constraint. There is insufficient of time to obtain adequate information and limits the location.

1.7 Chapter Outline

Chapter one consists of a brief introduction, background and context of the research. It explains the importance of this research in view the environmental problem and also the benefit and importance of recycling the construction waste. This chapter also contains the problem statement which mentioned about the problems or issues which are to be investigated in this study and the rationale of the research will be explained in this chapter. In addition, aim and objectives of the research are set and scope and limitation describes the scope and some constraints encountered in this research and the final part of introduction is the chapter outline which explains about the outline of the report.

Chapter two contains a review of literature about construction waste recycling. This chapter consists of definition and types of construction waste, construction waste generation that explains the sources of construction waste produced, construction waste management that describes the ways to manage waste and the final part is the construction waste recycling and its advantages.

Chapter three is research methodology which outlines the various approaches that have been used to conduct this research to data collection either primary or secondary data. This chapter is includes the research methodology process and research design.

In chapter four, statistical analysis will be carried out on the results obtained from questionnaire survey. It is followed by summary and critical review of the interviews.

Lastly, summary findings are drawn up from the analysis and supported by the data in chapter five. The second part will be the conclusion of the overall research based on the objectives. It is followed by recommendations on the construction waste recycling and further research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Construction waste is a serious environmental problem in many large cities (Chen and Li, 2006). According to the EU Waste Strategy, construction and demolition waste is considered to be one of the priority waste streams. Construction and demolition debris frequently makes up 10 to 30 percent of the waste received at many landfill sites around the world (Fishbein, 1998). Construction and demolition debris is waste material produced during construction, renovation or demolition of structures (Pichtel, 2005). Structures include residential and non-residential buildings as well as roads and bridges. The construction industry uses a wide variety of materials including lumber and wood, concrete and other masonry products, drywall, plastic and metal products. In addition, hazardous materials such as paints, solvents, and adhesives are used. Eventually, many of these materials become wastes.

The problem of material wastage is not an isolated issue on construction site. It is also an environmental concern. This problem arises can be caused by the depletion of natural resource, global warming, increasing pollution levels, and all of these issues are forcing the construction industry to take a more responsible attitude towards the environment. In Malaysia, the construction industry generates a lot of construction waste which cause significant impacts on the environment and increasing public concern in the urban areas (Begum et al., 2006).

In the framework of the Sixth Environment Action Program entitled Environment 2010: Our future, Our choice, actions need to be taken with respect to the effective management of this waste stream (European Community, 2001). According to Craven *et al*. (1994) and Johnston and Mincks (1995), waste management is made difficult in the construction industry due to the unique nature of each project, the hostility and unpredictability of the production environment, the fragmented nature of the project organizations used to procure buildings, and the intense cost and time pressures that characterize many construction projects. A successful construction and demolition waste management requires the efforts of varied team members each using their areas of expertise.

The construction industry plays a significant role in Malaysia's development both in the infrastructure and economic sectors. In Malaysia, the source of construction waste at the project site includes materials such as soil and sand, brick and blocks, concrete and aggregate, wood, metal products, roofing materials, plastic materials and packaging of products. Concrete and aggregate is the largest component with 65.8% followed by soil and sand (27%), 5% from wood based materials such as timber, lumber, etc., 1.6% from brick and block, 1% from metal products, 0.2% from roofing materials and 0.05% from plastic and packaging products such as papers, cardboards, etc (Begum et al., 2005).

Waste minimization and effective and sustainable waste management is a most pressing issue nowadays. It is important that waste minimization has to be embedded as one of the project objectives for that lead to sustainability. Three main waste minimization strategies of reuse, recycle and reduction, are collectively called the "3Rs". Waste minimization is the process of reducing the amount of waste produced by person or society and usually requires knowledge of the production process and detailed knowledge of the composition of the waste.

The hierarchy of disposal options, which categorizes environmental impacts into six levels, from low to high; namely, reduce, reuse, recycle, compost, incinerate and landfill (Peng *et al.,* 1997). Recycling and the environmental issue is the most concern agenda to the Malaysia government. Construction and demolition waste is an important resource which has the capability for recycling and reusing. Recycling,

being one of the strategies in minimization of waste, offers three benefits (Edwards, 1999):

i) reduce the demand upon new resources
ii) cut down on transport and production energy costs
iii) use waste which would otherwise be lost to landfill sites.

2.2 Definition of Construction Waste

Waste is best defined as any material by-product of human and industrial activity that has no residual value.

(Alarcon and Serpell, 1998)

Waste is defined as any substance or object that you discard, intend to discard, or are required to discard is waste and as such is subject to a number of regulatory requirements. Even if material is sent for recycling or undergoes treatment in-house, it can still be waste.

(EU Council Directive, 1975)

Construction waste is the byproduct generated and removed from construction, renovation and demolition work places or sites of building and civil engineering structures.

(Hong Kong Polytechnic, 1993)

Construction waste are in the forms of building debris, rubble, earth, concrete, steel, timber, and mixed site clearance materials, arising from various construction activities including land excavation or formation, civil and building construction, site clearance, demolition activity, roadwork, and building renovation.

(Shen *et al*., 2004).

2.3 Types of Construction Waste

Components of construction and demolition waste typically include concrete, wood, metals, gypsum wallboard, asphalt, and roofing material. Besides that, tree-stumps, rocks and soil are also included in construction and demolition waste. Typically, up to 10 percent of the materials delivered to a construction site become wastes (Magdich, 1995). Construction and demolition waste are made up of about 40 to 50 percent rubbish (concrete, asphalt, bricks, blocks and dirt), 20 to 30 percent wood and related products (pallets, stumps, branches, forming and framing lumber, treated lumber and shingles), and 20 to 30 percent miscellaneous wastes (painted or contaminated lumber, metals, tar-based products, plaster, glass, white goods, asbestos and other insulation materials, and plumbing, heating and electrical parts) (Tchobanoglous et al.,1993)

Table 2.1 lists the major components of construction waste and Table 2.2 lists the major components of demolition waste.

Table 2.1: Major Components of Construction Waste

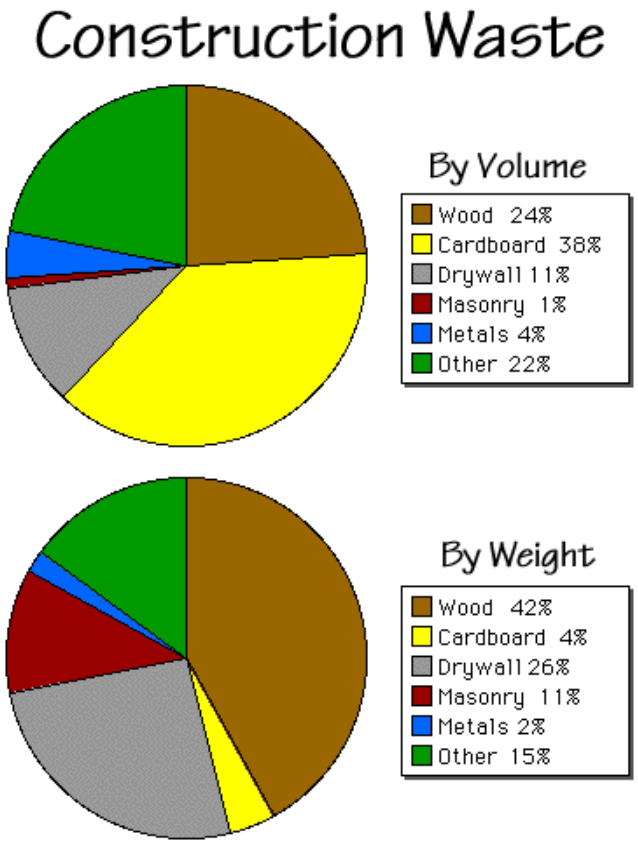
Construction waste
➢ Dimension lumber
➢ Plywood
➢ Concrete / masonry
➢ Metals
➢ Drywall plastics
➢ Carpet
➢ Cardboard
➢ Foam insulation
➢ Fibreglass
➢ Soil and land-clearing waste
➢ Hazardous waste (solvents/oils)
➢ Other

(Source from Magdich, 1995)

Table 2.2: Major Components of Demolition Waste

Demolition waste
➢ Dimension lumber
➢ Plywood
➢ Concrete / masonry
➢ Asphalt
➢ Reusable fixtures
➢ Metals
➢ Appliances
➢ Plastics
➢ Drywall
➢ Carpet
➢ Other

(Source from Magdich, 1995)



(Source from Oikos, 2007)

Figure 2.1: Types and Quantities of Construction Waste

Figure 2.1 shows the types and quantities of construction waste. From the information from Oikos (2007), there are some important generalizations about residential construction waste:

- By weight or volume, wood, drywall and cardboard make up between 60 and 80 percent of jobsite waste.
- Vinyl and metals are generated in small quantities, but have good recycling value.
- Cardboard waste is increasing on most jobsites as more components, such as windews, appliances, cabinets and siding, are shipped to builders over long distances.
- Most wood waste is “clean” - unpainted, untreated and recyclable. This usually includes dimensional lumber, plywood, and particle board without laminates.
- Brick, block and asphalt shingle waste are insignificant in volume, but can be important in terms of weight.
- For most builders, the largest share of waste that could be considered hazardous is generated from painting, sealing, staining and caulking.
- Drive-by contamination (waste placed in a container by a party other than the builder or subcontractor) can be as much as 30 percent of the total volume hauled from a site.

The difference in waste stream composition is tabulated in Table 2.3 and Table 2.4.

Table 2.3: Estimated Composition of Construction Wastes in Malaysia

Waste Type	**Percent (%) By Volume**
Dimension Lumber	25
Gypsum Wallboard	15
Masonry and Tile	12
Cardboard	10
Manufactured Wood	10
Asphalt	6
Other Wastes	5
Fibreglass	5
Other Packaging	4
Plastic and Foam	4
Metal	4
Total	100

(Source from Magdich, 1995)

Table 2.4: Estimated Composition of Demolition Wastes in Malaysia

Waste Type	**Percent (%) By Volume**
Wood Products	33
Masonry and Tile	13
Other	1
Concrete	53
Total	100

(Source from Magdich, 1995)

2.3.1 Asphalt

According to Tchobanoglous et.al, (1993), most asphalt waste comes from repaving projects. Asphalt paving is composed of a mixture of about 5 percent heavy oil and 95 percent aggregate. Crushed asphalt can be used as hot and cold mix asphalt for paving and pothole repair. Besides that, it also can be added to the production of new

roofing materials. Most old pavement that is reused is processed for road base, but up to 40 percent can be included in new pavement.

Old asphalt pavement is processed by itself or with concrete and other rubble; the mixture is crushed, ferrous metals are removed magnetically, and the crushed material is then screened to size. The grade material is supplemented with other crushed and screened rubble and is used as road base, or mixed with fresh asphalt binder to make new paving materials.

2.3.2 Brick

A brick is a block or clay tempered with water, sand, etc., molded into a regular form, usually rectangular, and sun-dried, or burnt in a kiln, or in a heap or stack called a clamp. In the United Kingdom, bricks have been used in construction for centuries. Until recently, almost all houses were built almost entirely from bricks. Although many houses in there are now built using a mixture of concrete blocks and other materials, but there are still many houses are skinned with a layer of bricks on the outside for aesthetic appeal.

Bricks from demolition activities may be contaminated with mortar, rendering and plaster, and are often mixed with other materials such as timber and concrete. Separation of the potentially valuable facing bricks will be usually difficult and require hand sorting. Any significant contamination of the bricks will render their uses uneconomically, as clean up costs for the cost of natural brick.

2.3.3 Cardboard

Cardboard or known as corrugated paper in the industry, is a heavy wood-based type of paper, notable for its stiffness and durability. Corrugated cardboard is made of

paper and consists of a fluted piece of paper between two flat liner boards. It is the most common building product packaging material.

Cardboard can be kept separate in cardboard-only dumpsters at the job site and picked up by a local recycling firm. Since there is more building components delivered to jobsites as finished products, the quantities are increasing. Although cardboard may not contribute much on the total weight, it can represent as much as 30 percent of the total volume. The major impediment for paper and cardboard recycling is site separation and the ability to provide an uncontaminated product that would meet the quality standards of the recyclers.

2.3.4 Concrete

Most concrete is recovered from roads, bridges and foundations. It s processed from road based, aggregate in asphalt pavement, and as a substitute for gravel aggregate in new concrete. Concrete chunks are crushed, ferrous materials such as bolts or reinforcing bar are removed, and the resultant aggregate is screened to sizes suitable for road building or new concrete. (Tchobanoglous et.al, 1993)

Concrete recycling is much more viable as a result of landfill costs for construction, demolition, and land-clearing debris is increasing, the expensive cost of trucking old concrete to the landfill and environmental concerns. In addition, concrete recycling has lower environmental impact. In terms of the overall environment, recycling concrete helps on saving energy compared to mining, processing and transporting new aggregates. Moreover, the large volume of concrete waste generated during demolition makes it difficult for landfills to accommodate. Recycling concrete from demolition project can result in considerable savings since it saves the costs of transporting concrete to the landfill and decrease disposal cost.

2.3.5 Drywall

Drywall also referred to as gypsum board, wallboard, plasterboard and rock wall. In United States, it is the primary material used for interior wall construction. Drywall is composed of a sheet of gypsum covered on both sides with a paper facing and a paperboard backing and it is commonly in 8 feet, 10 feet, or 12 feet long.

Most drywall waste is generated from new construction (64 percent), followed by demolition (14 percent), manufacturing (12 percent), and renovation (10 percent). Approximately 15 million tons of new drywall is manufactured per year in United States. About 12 percent of new construction drywall is discarded during installation (Pichtel, 2005).

Drywall waste from new construction sites is free of contaminants than demolition drywall and it is the most commonly recycled. While the drywall wastes from demolition sites may be recyclable for non-agricultural markets. There are some contaminants that need to be considered such as nail, tape, joint compound and the paint covered on drywall. Drywall is recycled by first separating the paper backing from the gypsum material. The paper can be recycled into new paper backing and the gypsum is remixed and used in the manufacture of new drywall. Due to the paper content of drywall waste will affects the fire rating, it will limits the amount of recycled gypsum allowed in new drywall.

Drywall can be recycled into new products, thereby (CIWMB, 2007):

- Creating business opportunities.
- Saving money for builders, contractors, and home renovators.
- Helping local governments meet their goal of reducing disposal by 50 percent.

New construction drywall can also be recycled into a soil amendment. Specific applications include (CIWMB, 2007):

- General agriculture
- Mushroom agriculture
- Forestry and mine land reclamation

- Nurseries
- City parks and recreation areas
- Residential lawns (sod)
- Golf courses
- Compost additives

2.3.6 Glass

According to Coventry (1999) stated that the glass industry recycled about 425,000 tonnes of glass in United Kingdom in year 1997. There are some uses for recycled glass in the construction industry. For example, glassphalt, window, fiberglass insulation, filling material, paving block and so on.

Fiberglass, a common alternative market for cullet, is predominantly used in the form of glass wool for thermal and acoustical insulation. Recycled glass used in the manufacture of fibreglass now constitutes the highest second volume of postconsumer glass (Pichtel, 2005). Glassphalt, another alternative promising market, is a road-paving material, which is a mixture of glass and asphalt that serves as a paving mixture for highway construction. It has been use as an alternative to conventional hot-mix bituminous asphalt pavement.

2.3.7 Masonry

The common materials of masonry construction are bricks, stone, concrete block, tile and so on. All these are laid or joint together using mortar. Masonry is a highly durable form of construction. There are some factors that can affect the quality of the overall masonry construction need to be considered such as the quality of the mortar and workmanship, and the pattern in which the units are assembled.

When constructing the retaining walls, or any other wall of buildings and as well as monuments, masonry is usually used. The most common type of masonry used globally is the brick masonry, either in solid or veneered. Brick veneer construction has strength imparted by a framework of wood of other material over which is placed of layer of bricks for weatherproofing and providing a finished appearance. The brick veneer wall is attached to the structural wall and connected to the structural walls by brick ties wall and mortar joints in between of the brick veneer. Brick of masonry wall typically will not require painting works and therefore can provide a structure with reduced life-cycle costs.

2.3.8 Metals

Metals such as aluminium, copper and steel are widely being utilized in the construction industries. It is an element, compound, or alloy characterized by high electrical conductivity. Metal is usually use in building steel home, steel roofing, clear span building and others construction works. They are usually have high density, ductile, malleable, have a high melting point and can conduct electricity and heat well.

Metals have the highest recycling rates among the materials recovered from the construction and demolition sites. Good markets have been in existence for ferrous metals as well as copper and brass. The recycling rate for construction and demolition steel is about 85 percent (18.2 out of 21.4 million tons generated) (Franklin Associates, 1998). Reinforcing steel used in foundations, slabs and pavement is usually recovered and sold to scrap dealers. Processors also reclaim nonferrous scrap such as aluminium window frames, screen doors, gutters and siding and copper pipe and plumbing fixtures (Tchobanoglous et.al, 1993).

2.3.9 Wood

Wood is one of the most versatile products in construction use. As a construction material, wood is strong, light, durable and flexible. Currently, many new domestic housing is commonly made from timber-framed construction. Besides that, wood will also be used as a supporting material, especially in roof construction, in interior doors and their frames, and as exterior cladding. In contrast to substitutes the wood in structural uses, wood can be transport and produce with little energy consumed and products are renewable.

Wood waste generated at construction sites is often of better quality and purity and has a better potential for reuse than from demolition sites, as the former material is more easily separated from other wastes. Demolition wood is often low in demand because of contamination and due to the difficulty in separating wood from other building materials (Pichtel, 2005).

Construction and demolition wood wastes consists of framing and form lumber, treated wood, plywood and particle board and wood contaminated by paint, asbestos or insulation. Wood wastes are typically shredded in a tub or other commercial wood grinders and passed through a classifier or trammel, where the oversized pieces are separated. Ferrous metals are removed magnetically and the fines (undersized materials, which are often sold for mulch or oil amendments), are separated by screening (Tchobanoglous et.al, 1993).

2.4 Construction Waste Generation

Construction and demolition activities generate very large quantities of solid waste. It is generated when new structures are built and existing structures are renovated or demolished. In rapidly growing areas, the construction and demolition waste stream consists primarily of construction debris, with only small volumes of demolition debris. In contrast, in older urban areas demolition debris makes up the majority of the construction and demolition waste stream (Pichtel, 2005). The sources and the

components of construction and demolition wastes vary mainly depending on the mature of the project, activities involved and geographical location.

Construction and demolition waste can arise from the construction process from a very beginning process such as site clearing right through the end of the construction for roof top. According to Graham and Smithers (1996), throughout the life cycle of a construction project, there are a number of factors leading to the production of wastes. The implications of the five phases, namely, design, procurement, materials handling, construction/renovation, and demolition to the waste generation are described by Graham and Smithers (1996) as follows:

Table 2.5: Causes of Waste in Different Project Phase

Project Phase	**Cause of Waste**
Design	Plan errors Detail errors Design changes
Procurement	Shipping error Ordering error
Materials Handling	Improper storage Deterioration Improper handling (on-site or off-site)
Construction/Renovation	Human error Tradesperson Other labour Equipment error
Demolition	Tipping

2.4.1 Design

It is important that designers are responsible for introducing and planning waste minimisation strategies from the earliest stages of design through to completion which includes in deciding what to build, whether to demolish, what materials to use

and how they might be recycled. Carelessness at the design stage can lead to the excessive cutting wastes and create a shortage of materials on site. Architectural design and rare standard formwork and components can also greatly affect the constructability and assemblies of a building. Plan errors or incomplete details, as a result of time constraint, can also cause variations that require input of additional materials.

2.4.2 Procurement

Generally, fault in taking-off, unfinished detailing are the main factors that caused over-ordering of materials. Besides that, material damages can also caused by lack of care during transportation.

2.4.3 Materials Handling

Inappropriate storage always causes damage or deterioration for the material handlings. Consequently, waste results from bad stacking, rusting of steel, damage and aging of formwork, etc. There are several ways to minimise the problems such as the following:

- Minimise time between delivery and installation and the risk of damage or theft.
- Have fragile materials and fixtures delivered and installed close to completion date.
- Use prefabricated framing and trusses to reduce time on site before installation.
- Check quantity, condition and quality on delivery. Report discrepancies immediately.

- Reject inferior goods or materials if their quality will result in additional waste.
- Refuse oversupply as compensation for inferior quality or condition.
- Report careless delivery staff to the supplier.

2.4.4 Construction

The construction process accounts for the physical generation of waste materials. Human errors are lack of supervision by main contractors over the labour and sub-contractors on the site where works are differently distributed. Over-mixing and materials surplus frequently happen for wet trades like concreting and brick or block walling because the raw materials are usually packed in bag or box and the excess mixed materials cannot be reused. Malfunction of equipment or carelessness of worker using equipment can also cause damage to materials and subsequently waste is unavoidable.

2.4.5 Renovation

Refurbishment and renovation works are the process of restoring or improving a structure whether aesthetically or mechanically. Two prominent types of renovation are commercial and residential. Renovation works are more popular nowadays due to soaring real estate prices.

2.4.6 Demolition

Demolition at the end of a building's operational life and subsequent tipping of materials also create a large proportion of wastes. Demotion is carry out when old building is to be demolished due to deterioration of the building or to make way for

construction of a new building. Demolition contractor should specialize in planned deconstruction so that recovery of good material can be maximized for re-use.

2.5 Construction Waste Management

Construction waste has a major impact on the environment and is becoming a worldwide problem. In Malaysia, due to the commercial building and housing development and also the demands in implementing major infrastructure projects, there is a large amount of construction waste is being produced by the construction sector. Waste became more harmful to health and to natural environments as a result of waste quantities accumulated and increased. Therefore, the construction waste management is an important area of concern in the construction industry of Malaysia.

Construction waste management is to enhance a builder's operation and image, as well as the image of the entire home building industry. The construction waste management plan implemented represents the first steps in developing a holistic strategy for minimizing waste generation from the construction process (Mcdonald and Smithers, 1998)

Waste management also includes handling of waste, which including treatment, storage and disposal (Abbas, 2002). Moreover, it is important to know the composition and quantity of the waste so that disposal can be handled in a planned manner. Waste minimizing is not only to reduce production costs but also to reduce liability at the same time. The general contractor bears some responsibility for any waste generated from unauthorized or illegal disposal of wastes, particularly potentially hazardous wastes at jobsites and to protect the company from any potential liability.

In order to reduce the total disposal cost, reduce and recycling are the most effective ways to manage the construction and demolition wastes. Besides that, it is important that the contractors should use materials efficiently to avoid pay twice for the materials wasted on job sites. Furthermore, resource conservation also should be

considered. Contractors is responsible to do their part to conserve natural resources and landfill space by looking at their waste stream and seeing resources instead of refuse.

According to Kreith and Tchobanoglous (2002), there are four options of the management of construction and demolition waste, which is source reduction, reuse, recycling and landfilling.

2.5.1 Source Reduction

Source reduction involves the use of processes, practices or products to reduce or eliminate the generation or the toxicity of pollutants and wastes. Source reduction includes, but is not limited to, material substitution, process substitution and process elimination (Abbas, 2002). According to Kreith and Tchobanoglous (2002), source reduction involves reducing the amount of material used through more careful estimating to eliminate waste.

Reduction is the most efficient method to minimize the generation of solid waste. Source reduction does not incur costs for waste handling, recycling, and disposal for waste that is never created. Hazardous materials are usually the main target for reduction. Moreover, the rising of hazardous waste disposal costs would encourage the contractor to reduce it.

2.5.2 Reuse

Reuse techniques is defined as re-employment of materials to be reuse in the same application or to be used in lower grade applications. Once the wastes generated cannot be reduced or unavoidable, reuse techniques is a desirable option.

A variety of reusable and unused materials could be found in construction activity such as lumber of different sizes, piping, plywood, asphalt shingles and so on. The re-use of products or materials that would otherwise become waste can provide a range of social, economic and environmental benefits. Many building materials may be reusable during renovation projects where a new building is built following the demolition of another (Matthew, 2009).

2.5.3 Recycling

Recycling is the reprocessing of a reclaimed material and converting it into a new material or use. Reuse and recycling opportunities for construction and demolition wastes depend on the markets for the individual materials comprising the wastes and the ability to process the commingled waste or separate the individual materials (Kreith and Tchobanoglous, 2002).

The benefits from waste recycling are not solely environmental, but economic and aesthetic as well. Recyclable materials have differing market values depending on the presence of local recycling facilities, reprocessing costs, and the availability of virgin materials on the market (Matthew, 2009). In general, it is economically feasible for construction sites to recycle those waste materials.

Significant strides have been made in the recycling over the years and it is possible to believe that there will be greater amounts of construction and demolition waste be recycled in the future due to the environmental concerns, increasing cost for the disposal of construction and demolition waste by landfilling, higher tipping fees and the success of entrepreneurs in processing both source-separated and mixed wastes.

2.5.4 Landfill Disposal

Disposal is the “no alternative” option because it is the last functional element in the solid waste management system and the ultimate fate of all wastes that are of no further value (Tchobanoglous, 1993). According to Pichtel (2005), construction and demolition waste is commonly managed via landfilling. There are some management concerns that must be considered such as environmental impact, public concerns and the adaptability for multiple uses in the waste management system.

In the management of existing landfills, the major concern is to ensure that proper operational procedures are followed carefully and routinely. The basic issues for the planner and manger are (Tchobanoglous, 1993):

i) Justification of need for a landfill
ii) Evaluation and community acceptance of the landfill location
iii) Landfill design and cost-effectiveness
iv) Management policies and regulations

2.6 Construction Waste Recycling

Recycling is the removal of material from waste for reprocessing. Recycling is recognized today as a solid waste management strategy that is preferable to landfilling or incineration and environmentally more desirable (Ruiz, 1993).

Recently, increased awareness of the environment, concern over guaranteeing sustainable development, and aware of the need to organize waste management have all contributed to enhancing the image of recycling as an important instrument to attain these environmental objectives. The recycling of waste materials has many benefits, which will indirectly protect the natural environment.

In almost all communities in the country today, there is a growing concern for recycling and the environment. The true success of a construction and demolition waste recycling operation must be determined by establishing the scale of the

operation to be implemented and its resulting economics (Peng et al., 2010). Before establishing a waste recycling operation, it is important to identify all possible alternatives.

2.6.1 Advantages of Recycling

Recycle technique is defined as utilizing wastes as raw materials in other applications. It takes less energy to process recycle materials than it does to use virgin materials. According to Matthew (2009), the advantages of a construction and demolition recycling program include:

- Avoid trash collection and disposal fees
- Save resources and money through deconstruction
- Improve organization's public image
- Make new products from old materials
- Improve the market for recycled content products
- Help community meet local and state waste reduction goals

2.6.1.1 Avoid Trash Collection and Disposal Fees

By recycling the waste materials, the amount of waste can be reduced. Besides that, recycling can helps to reduce the overall construction costs through avoiding the disposal fees and recycling and also create competitive advantage by doing so. Contractors can also expect to create markets by providing feedstock for the manufacture of new materials.

2.6.1.2 Save Resources and Money Through Deconstruction

Recycling also helps to save the natural resources such as wood, water and minerals. This can be seen by throwing away a single aluminium can is like pouring out six ounces of gasoline. By reusing materials and re-manufacturing them into new products we are reducing the amount of virgin natural resources that we need to use.

Deconstruction is an expression describing the process of selective dismantling or removal of materials from buildings before or instead of demolition (Matthew, 2009). For example, doors and windows can be refinished for reuse in the new construction. In addition, the amount of contamination of the waste affects the recyclability of demolished materials. Demolished wood is usually not recyclable unless it is deconstructed and the nails are removed. Also, by donating the reusable excess construction and demolition debris, a business not only helps to keep reusable material out of landfills and incinerators, but can also help to reduce costs for future projects (Matthew, 2009).

2.6.1.3 Improve Organization's Public Image

By reducing the amount of waste and using fewer resources, it can boost the public image of companies and organizations that recycle in the communities and its customers. Recycling practices is a great boost for a company's public image. It will be seen as company that does the responsible thing. What is really even better is that it is also cutting costs and helping to gain profit at the same time.

2.6.1.4 Make New Products from Old Materials

Construction and demolition waste also can be recycled and processed into new products. For example, recycling metal can create new parts for cars and buildings, as well as containers for food. In United States, the construction and demolition

wastes have been recovered and processed into recycled content products. Paper, the number one solid waste product in the United States and it takes 40 percent less energy to make paper from recycled paper than from fresh wood.

2.6.1.5 Improve the Market for Recycled Content Products

Because of the effort being exerted to develop markets for recovered materials, the numbers of construction and demolition facilities are continuing to grow. According estimation by Construction & Demolition Debris Recycling magazine, there are more than 3500 construction and demolition debris recycling facilities in operation throughout the United States (Matthew, 2009).

2.6.1.6 Helps Community Meet Local and State Waste Reduction Goals

Many communities have established waste reduction goals, since construction and demolition projects generate a large amount of debris. Finding new users or recycling theses materials can significantly help in these efforts (Matthew, 2009).

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

In order to ensure the effectiveness and smoothness of the study process, it is essential to have a well-organized research methodology. Essentially, the procedures by which researchers go about their work of describing, explaining and predicting phenomena are called research methodology.

It is important to design a methodology and give the work plan of research. Study will be conducted following predetermined plan under systematic steps to find the answer of the study questions. Besides that, in order to obtain all the information and data needed and to ensure a reliable and good result on the study, it is necessary to have a thorough planning organized in proper sequence which outlines the various stages in collecting information and data.

Generally a study methodology is planned by stages according to their priorities and functions. The research work will be divided into few steps in logical and coherent order and provide answers under the scope of research. There are five stages in this research which include formulating a research problem, reviewing literature, collecting data, analyzing data and conclusion.

3.2 Research Methodology Process

The research procedure is shown in the flowchart below:

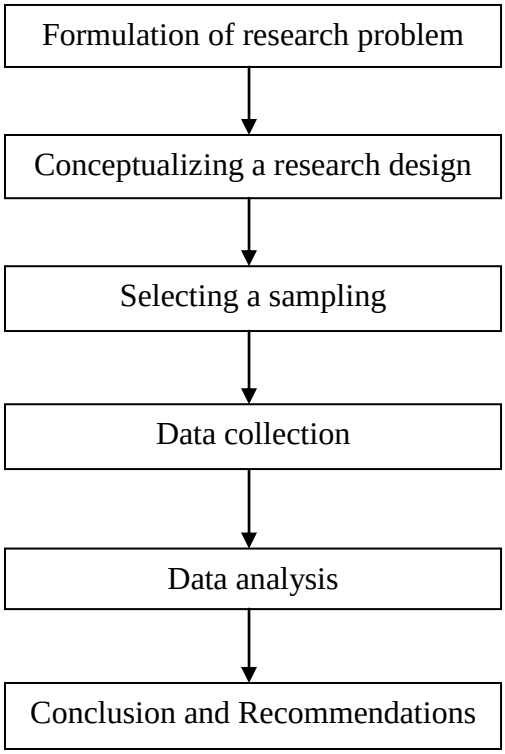


Figure 3.1: Flowchart of Research Methodology

3.2.1 Formulation of Research Problem

The most primary step is formulating a research problem. The researcher will need to identify the aim and objectives of their research study. The purpose of formulating the research problem is to let the researcher to know what they planning to do and accomplished in the research.

Identifying of a research problem opens up new questions and possibilities. It is an opportunity to test new ideas or re-interpret old problems from a fresh perspective (Tan, 2007). It is important to consider the ability to conduct the research in terms of time, cost, and skill in selecting the topic. Preliminary literature scan is often help to delimit the scope of research and develop the research title of the study.

3.2.2 Conceptualizing a Research Design

Research design is a plan, structure and strategy of investigation so conceived as to obtain answers to research question problems. The plan is the complete scheme or program of the research. Research design is planned after defining research objectives. A research design would specify the methods and procedures for collecting and analyzing the wanted information. After that, the sampling of methodology, design techniques and the sources of information will be determined.

3.2.3 Sampling

Sampling refers to the process of selecting a portion of the population to represent the entire population. It is necessary to obtain data only a part of the total population. That part of the population is the sample. The objective of sampling is to provide a practical means of enabling the data collection and the processing components of research to be carried out whilst ensuring that the sampling provides a good representation of the population (Fellows and Liu, 2003). Sampling is helping to gain an understanding about some feature or attribute of whole population.

In this research, the questionnaires will be sent to the contractor's firm which is in Klang Valley. The targeted sampling size was minimum 20 respondents and the numbers of persons to be interview are targeted to minimum 2 contractors.

3.2.4 Methods of Data Collection

After determining the research design, the next step in the research process is to select the methods of collecting data such as questionnaires and interviews, observation techniques, analysis of past documents and simulation (Tan, 2007). There are two main data approaches to data collection known as primary data or 'fieldwork' and secondary data or 'desk study' (Naoum, 2001).

Firstly, secondary data collection has been carry out by reviewing literatures on the related area. After that, questionnaire survey and personal interview will be adopted for primary data collection.

3.2.4.1 Questionnaire

A questionnaire is a research instrument consisting of a series of questions and other prompts for the purpose of gathering information from respondents. Questionnaires are very useful in getting data from a relatively large number of people or from a representative sample of that population. Questions occur in two primary forms, which is open or closed. Closed-ended questionnaires, which every question having a fixed range of alternative responses will be used in the questionnaire survey. Close-ended questions are more easily analyzed and can be more specific because open-ended questions allow respondents to express their views in their own words.

3.2.4.2 Interview

An interview is a conversation between two or more people where the questions are ask by the interviewer to obtain information from the interviewee. Interviews may be structured along a pre-determined questionnaire, semi-structured or loosely structures. The latter is common in in-depth interviews where probing questions are asked (Tan, 2007).

Interview is a commonly used method of collecting information as well as opinion in the research study. The data collected will usually be richer and more contextual information and it provides an opportunity for the interviewee to give a more detailed response. Personal interviews are used if probing questions are involved or visual demonstrations are required. Personal interviews were conducted in this research in order to collect in-depth information concerning the construction waste recycling issue.

3.2.5 Collection of Data

The data collected using the fieldwork approach which are obtained first hand are called primary data collection. Primary data are often collected for methodologies that use the case study, experimental and survey designs (Tan, 2007). For example, use questionnaire or personal interview method to get the data or information from different construction personnel.

While the secondary data are collected using the desk study approach which are obtained from the published material in some form that is fairly accessible. Secondary data are often used in studies using regression, comparative and historical designs (Tan, 2007). The source of literature reviews are normally obtained from published journals, books and so on.

3.2.6 Data Analysis

Analysis of data will be done according to the result achieved. The data and information from the survey forms were all analyzed by using likert scale and other suitable statistical methods. Results and answer from the analysis is organised and presented in suitable forms such as charts, tables or graphs. Thus, the data could be interpreted and understood easily.

3.3 Research Design

Research design can be defined as a plan outlining how information to be gathered for an assessment or evaluation that includes identifying the data gathering methods, the instruments to be used, how the instruments will be administered, and how the information will be organized and analyzed. A research design is a plan for testing the hypothesis. The purpose of a research design is to rule out alternative explanations or false conclusions (Tan, 2007).

The choice of a particular research method typically depends on the purpose of the study and the type and availability of the required data (Naoum, 2001). The methods and procedures for collecting and analyzing the information would be specified in a research design. After that, determine the sources of information, sampling and the methods of data collection. In addition, time and cost constraints are also taken into consideration in methodology design.

The design for this study is conducting questionnaires and interviews which had been selected as the methods of data collection. The data collection for this study was obtained from literature review and questionnaire survey, and interviews. The intent of this research design is to identify the construction materials which could be recycled, the methods used to dispose of the construction waste and the advantages of recycling the construction waste.

A total of 30 survey questionnaires were sent to different construction parties within Klang Valley. The questionnaires consist of two sections with a total fifteen questions. There are two questions in section A which was about the background of the respondents. Section B consists of thirteen questions collecting data regarding the types of construction waste and recycling of the construction waste. Moreover, closed-ended questions will be used in the questionnaire survey. Data analysis of survey questionnaire will be carried out by calculating percentages or ranking according to the importance index which is calculated by using likert scale.

$$\text{Importance Index} = \frac{5(N1)+4(N2)+3(N3)+2(N4)+1(N5)}{5(N1+N2+N3+N4+N5)}$$

N1 = Number of respondents who tick “most frequent/most important/high cost”

N2 = Number of respondents who tick “very frequent/very important/moderately high cost”

N3 = Number of respondents who tick “moderately frequent/moderately important/medium cost”

N4 = Number of respondents who tick “less frequent/lea important/moderately low Cost”

N5 = Number of respondents who tick “least frequent/least important/low cost”

Besides that, personal interviews were carried out in order to get a thorough and clearer picture and obtain more information on waste recycling of the construction industry in our country. Interviews are more effective as the contractors are able to describe in detail the problems that faced when recycling and what can be done to increase the recycling of construction waste in our country.

CHAPTER 4

ANALYSIS AND DISCUSSION

4.1 Introduction

In this chapter, analysis and discussion of result obtained from survey questionnaires and interviews is done. Data were obtained by conducting questionnaire survey and interview with construction parties. Besides that, summary of interviews will be generated in the subsequent section. Critical review of interviews also will be carried out in this chapter.

4.2 Survey Questionnaire

There were total of 30 set of survey questionnaires were sent to different construction parties in Klang Valley such as contractor, project manager, engineer, site manger and other various parties who involved in the construction field. All of the survey questionnaires had been successful collected which representing a response rate of 100%. The analysis was carried out based on the 30 questionnaires returned.

4.2.1 Section A: Respondent's Background

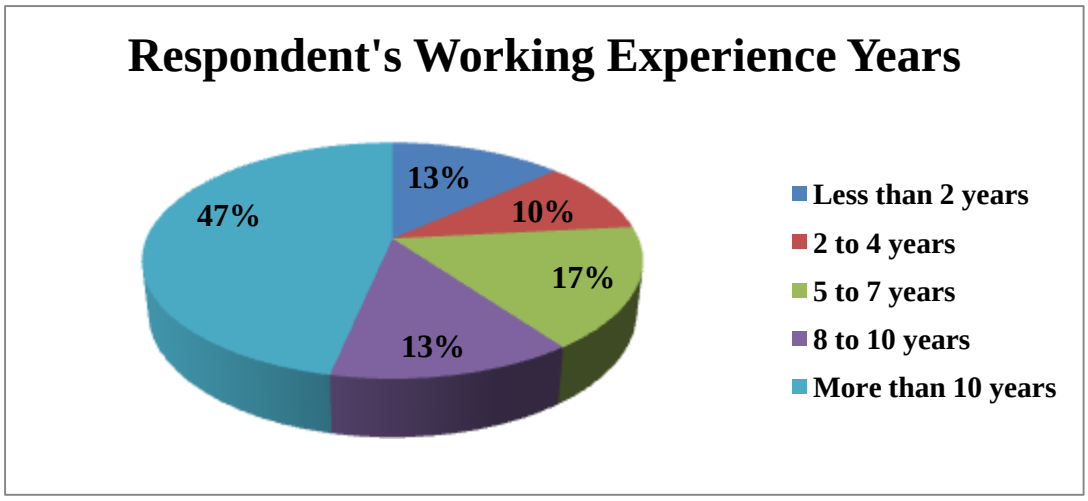


Figure 4.1: Respondent's Working Experience Years

Figure 4.1 above shows the working experience year of the respondent in the construction industry. The chart indicated that respondents with working experience more than 10 years in construction industry forming the largest percentages and consists of 47 %. There are only minority of the respondents has working experience with 2 – 4 years which is 10 % of the respondents. This indicates that majority of the respondents were qualified to answer the questionnaire based on their experience.

4.2.2 Section B: Types of Construction Waste and Their Recycling

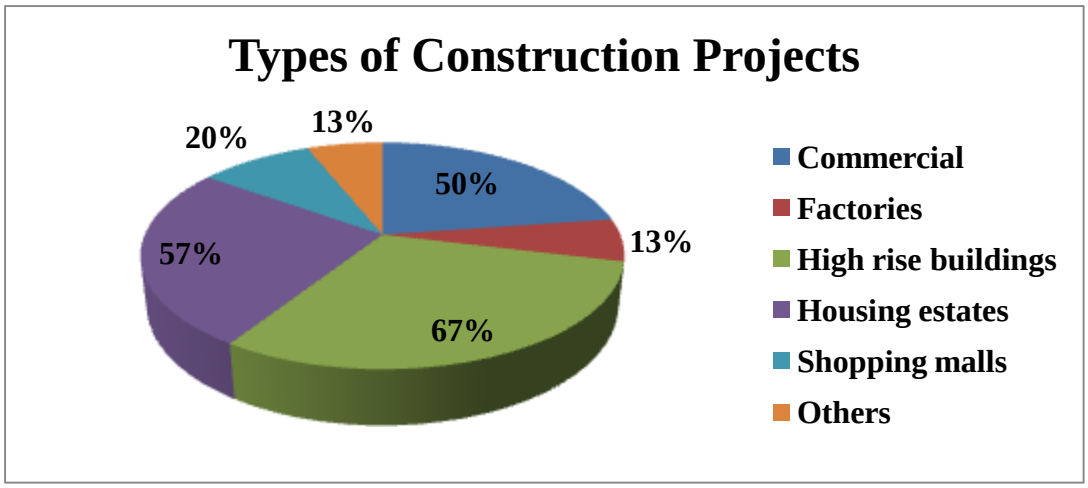


Figure 4.2: Types of Construction Projects

Figure 4.2 shows the different types of construction projects which have been carried out by the various respondents. The type of construction project that have been carried out mostly is high rise buildings which consists of 67 %. The results show that there are 57 % of the respondents carried out the construction projects on housing estate, 50 % on the commercial building, 20 % on the shopping malls and only minority of the respondents are carried out construction projects on factories which is 13 %. The other types of construction projects which is consists of 13 % are such as civil and infrastructures works, external infrastructure works, hospital and school.

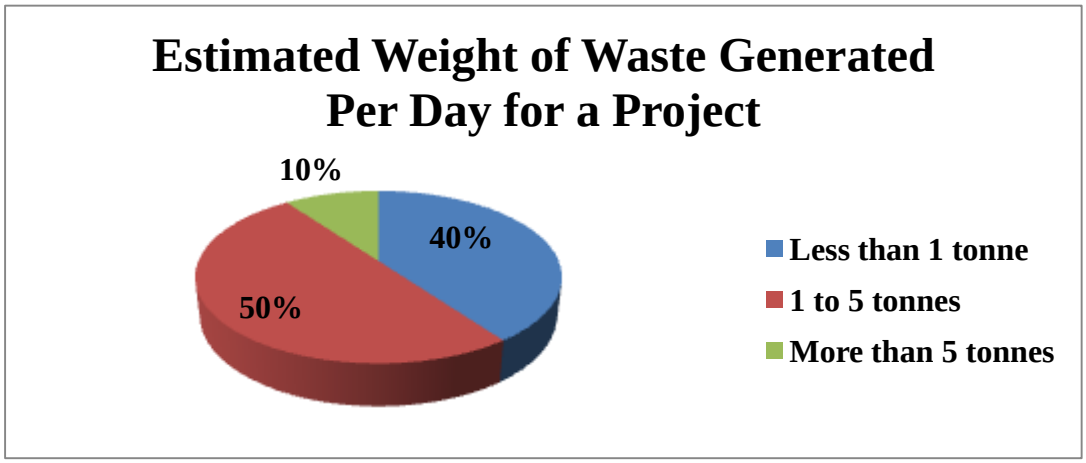


Figure 4.3: Estimated Weight of Waste Generated Per Day for a Project

The pie chart in Figure 4.3 shows the estimated weight of waste generated per day for a construction project. The results show that most of the waste generated in construction project is about 1 to 5 tonnes. Besides that, the construction waste generated which is less than 1 tonne has forming quite large percentages, which contains of 40 %. There is only small percentage of waste generated in the construction projects is more than 5 tonnes.

Table 4.1: Importance Index of the Waste Materials Generated on Site

Construction Waste Materials	Degree of Importance					Importance Index	Overall Rank
	5	4	3	2	1		
Asphalt	2	2	3	9	14	0.3933	9
Brick / Block	10	10	7	0	3	0.7600	2
Cardboard	1	2	6	10	11	0.4133	8
Concrete	10	7	5	1	7	0.6800	4
Drywall / Wallboard	0	6	8	11	5	0.5000	6
Glass	3	5	4	8	10	0.4867	7
Masonry / Mortar	12	5	7	5	1	0.7467	3
Metals	5	10	6	4	5	0.6400	5
Wood / Timber	11	10	6	3	0	0.7933	1

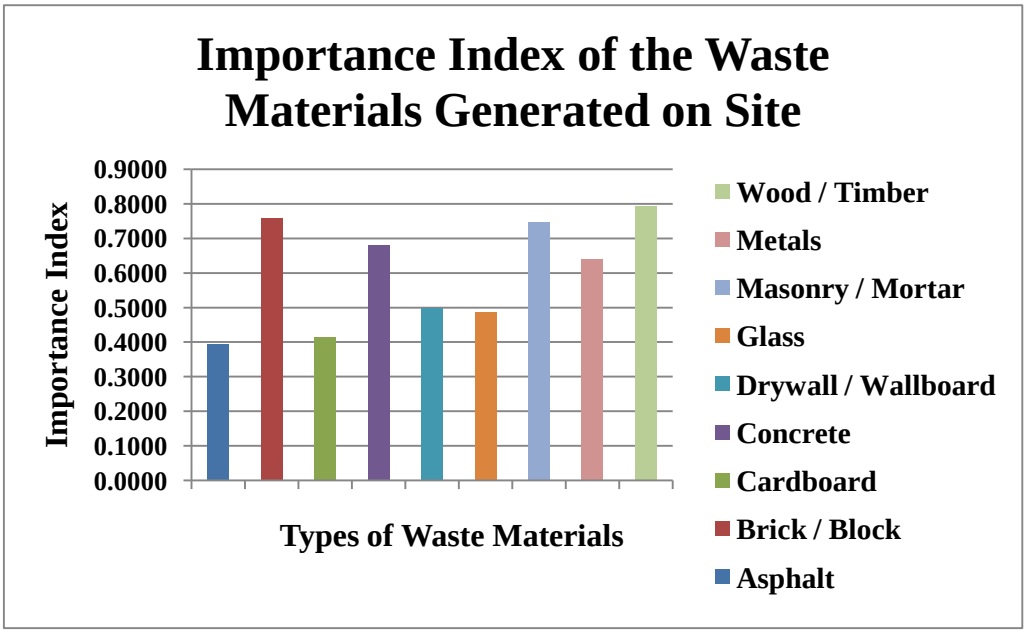


Figure 4.4: Importance Index of the Waste Materials Generated on Site

Table 4.1 and Figure 4.4 show the importance index and ranking of the construction waste materials generated on site. There are nine types of waste materials which are specified in the literature review. From the result above, it can be observed that wood/timber which has the highest importance index is the major sources of the waste materials generated on site. Besides that, brick/block and masonry/mortar have also contributed to a significant portion of waste materials generated on site.

Various functions of wood/timber in the construction works may be the causes of wood/timber having the highest important index. From the literature review, wood will also be used as a supporting material, especially in roof construction, in interior doors and their frames, and as exterior cladding. In contrast to substitutes the wood in structural uses, wood can be transport and produce with little energy consumed and products are renewable. Other than that use in construction works such as roof trusses, wood/timber also use in formwork may result in the wood/timber.

Table 4.2: Importance Index of Frequently Recycled Waste Materials

Construction Waste Materials	Degree of Importance					Importance Index	Overall Rank
	5	4	3	2	1		
Asphalt	2	1	4	4	19	0.3533	8
Brick / Block	1	2	10	10	7	0.4667	3
Cardboard	0	1	10	8	11	0.4067	4
Concrete	0	0	2	10	18	0.2933	9
Drywall / Wallboard	0	3	6	9	12	0.4000	5
Glass	1	4	2	4	19	0.3600	7
Masonry / Mortar	0	1	7	9	13	0.3733	6
Metals	11	5	7	3	4	0.7067	1
Wood / Timber	7	8	9	4	2	0.6933	2

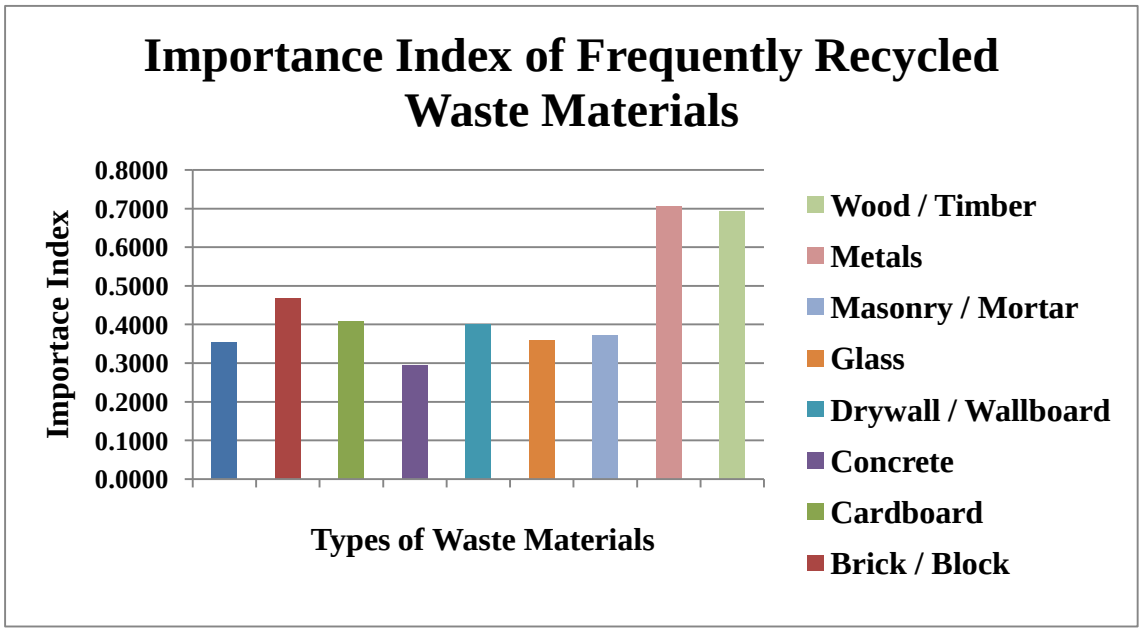


Figure 4.5: Importance Index of Frequently Recycled Waste Materials

The importance index and ranking of waste materials which are frequently recycled are tabulated in Table 4.2. From the analysis of importance index, it was found that the waste materials that are most frequent recycled are metals with an importance index of 0.7067. From the literature review, metals have the highest recycling rates among the materials recovered from the construction and demolition sites. Good markets have been in existence for ferrous metals as well as copper and brass. Nowadays, there are many types of metals used for building. The recyclability of metals enables metal construction products to be included in listings for "green" or sustainable building materials.

Wood/timber which possesses second highest importance index is also one of the frequently recycled materials. According to the literature review, wood waste generated at construction sites is often of better quality and purity and has a better potential for reuse than from demolition sites, as the former material is more easily separated from other wastes. Recyclable wastes such as wood/timber can be converted into site hoarding and workers' quarters. Furthermore, wood from formworks or roof trusses may also be able to be reused in their original functions.

On the other hands, the material that seldom recycled is concrete which has the lowest importance index of 0.2933. Besides that, there is also a few of respondents had specified some of the other types of construction waste that are frequently recycled such as tiles, stone, sealant and black oil or hydraulic oil from machinery.

Table 4.3: Importance Index of Waste Materials Based on Their Recycling Cost

Construction Waste Materials	Degree of Importance					Importance Index	Overall Rank
	5	4	3	2	1		
Asphalt	4	0	7	7	12	0.4467	8
Brick / Block	2	4	9	9	6	0.5133	6
Cardboard	0	2	9	8	11	0.4133	9
Concrete	3	3	6	16	2	0.5267	4
Drywall / Wallboard	2	7	10	6	5	0.5667	3
Glass	6	4	10	4	6	0.6000	2
Masonry / Mortar	2	5	3	16	4	0.5000	7
Metals	6	8	6	9	1	0.6600	1
Wood / Timber	2	5	10	5	8	0.5200	5

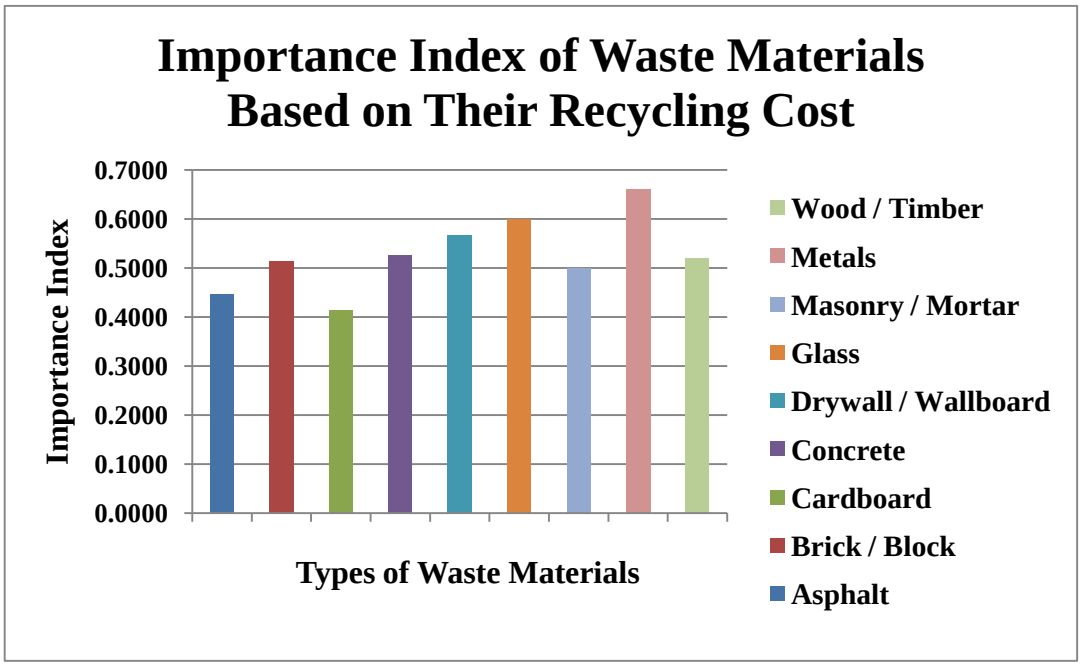


Figure 4.6: Importance Index of Waste Materials Based on Their Recycling Cost

The data in Table 4.3 and Figure 4.6 above were obtained from the respondents depends on the important factors that encourage construction waste recycling. It can be observed that metals that possesses the highest importance index at values of 0.6600 which indicates that it has the highest recycling cost, while cardboard has the lowest recycling cost.

Although metals require high cost to recycle, there are many benefits of metals recycling. By recycling metal such as aluminium and steel, it helps to reduce greenhouse gas emissions and also decrease environmental damage that caused by mining. Furthermore, recycling metal products uses less energy than manufacturing it from new materials. The use of recycled metal can also contribute significantly toward a building acquiring LEED (Leadership in Energy and Environmental Design) certification points.

Table 4.4: Importance Index of Factors Leading to the Production of Construction Wastes

Construction Waste Materials	Degree of Importance					Importance Index	Overall Rank
	5	4	3	2	1		
Design	12	10	6	1	1	0.8067	3
Procurement	2	6	15	4	3	0.6000	6
Materials handling	14	10	4	1	1	0.8333	2
Construction	10	11	8	1	0	0.8000	4
Renovation	5	15	6	3	1	0.7333	5
Demolition	16	9	3	1	1	0.8533	1

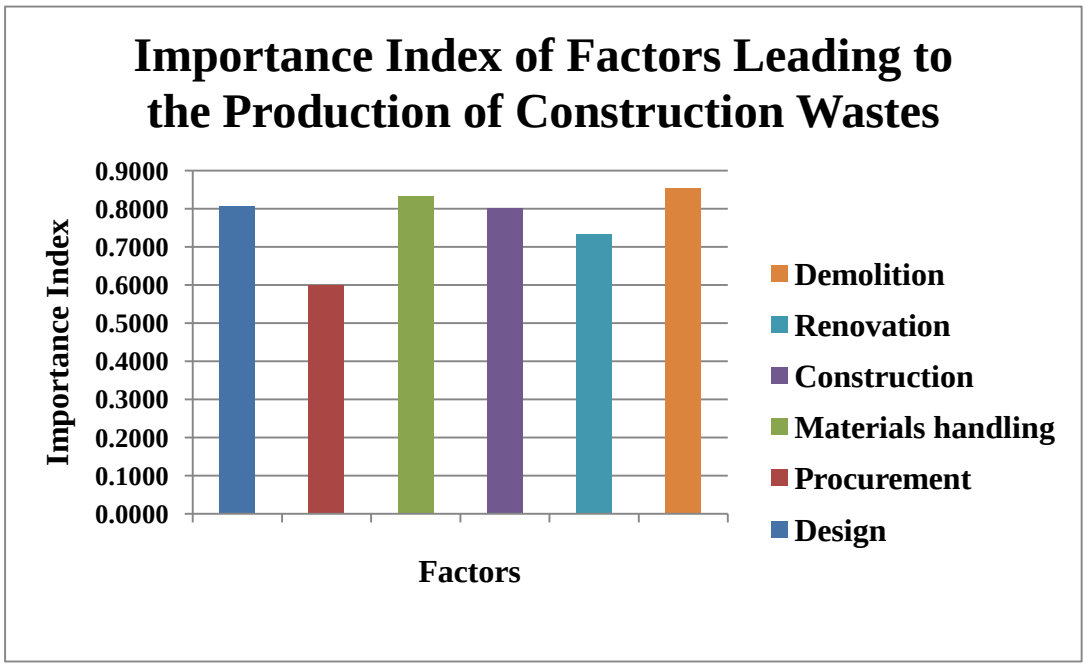


Figure 4.7: Importance Index of Factors Leading to the Production of Construction Wastes

From the literature review, there are six types of factors which caused construction waste generation which includes design, renovation, construction, materials handling, procurement and design. Important Index of factors leading to the

production of construction wastes was shown in Table 4.4 and Figure 4.7. Data were obtained from the respondents depends on the importance factors that leads to the production of construction wastes.

From the analysis of importance index, the most important factor that leads to the production of construction wastes is demolition that has the highest importance index of 0.8533 while procurement possesses the lowest importance index at value of 0.6000. Demolition is a very important factor which causes generation of waste. It is the tearing-down buildings and other structures where a site is cleared of its building. Therefore the waste generated from demolition is generally much higher than the other factors. Other than those factors specified in the questionnaire, one of the respondents had specified management as a quite important factor that causes waste generation.

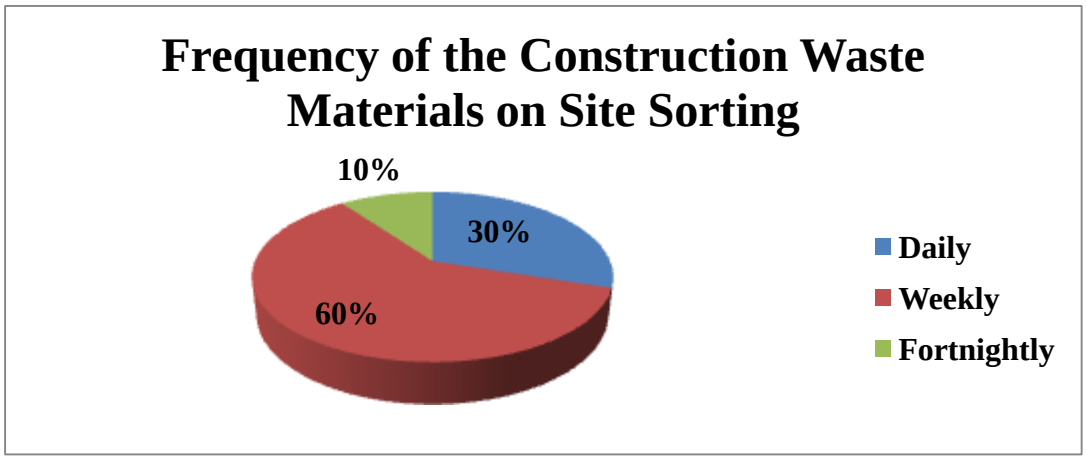


Figure 4.8: Frequency of the Construction Waste Materials on Site Sorting

Figure 4.8 illustrates the frequency of the company respondents' company practice on site sorting of construction waste materials. It was found that most of the company practice on site sorting of construction waste materials weekly and there is only small percentage that practice fortnightly.

Table 4.5: Importance Index of the Methods of Waste Minimization During Construction Works

Construction Waste Materials	Degree of Importance					Importance Index	Overall Rank
	5	4	3	2	1		
Careful evaluation of materials so that over-ordering and site wastage is reduced	14	12	3	0	1	0.8533	1
Reduce the amount of packaging	1	3	14	6	6	0.5133	5
Practice just-in-time delivery to minimize damage to materials during on-site storage	4	12	10	3	1	0.7000	2
Reuse or recycle packaging of materials	1	6	12	7	4	0.5533	4
Use recycled materials	1	8	10	9	2	0.5800	3

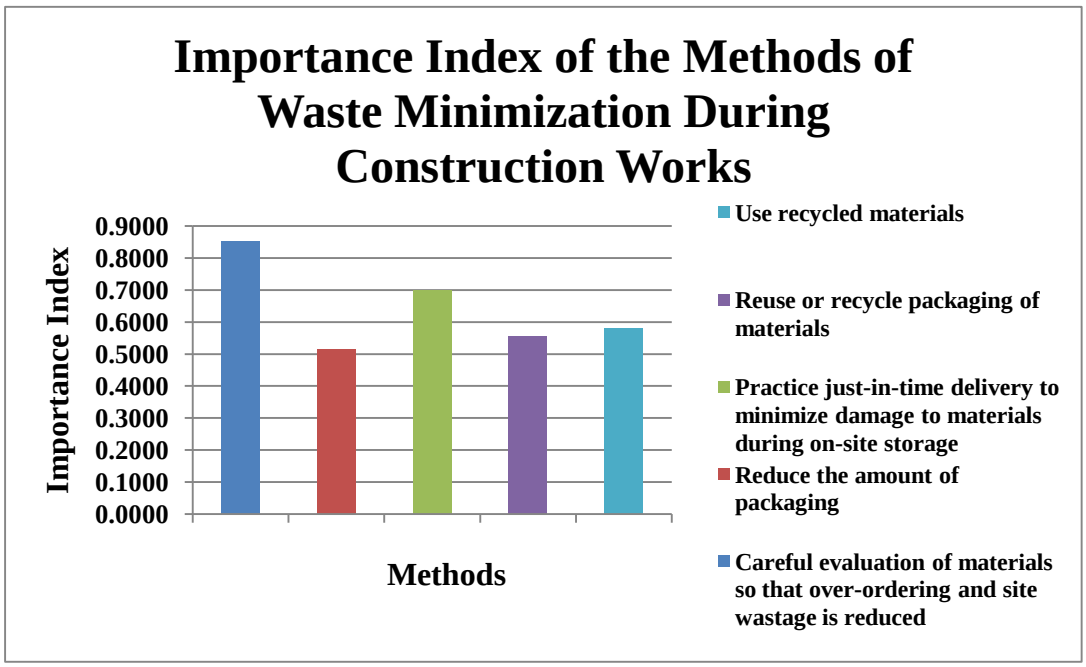


Figure 4.9: Importance Index of the Methods of Waste Minimization During Construction Works

The data tabulated in Table 4.5 were obtained from the respondents depends on the importance of the methods of waste minimization during construction works. The results above shows that the most important method of waste minimization during the construction works is careful evaluation of materials so that over-ordering and site wastage is reduced. Reduce or avoid over-ordering of materials is very important as damage may resulting from poor storage or because the materials ordered are inappropriate.

On the other hand, the respondents had also ranked reduce the amount of packaging is the infrequent methods used to minimize waste during the construction works. This may due to by reducing the amount of packaging, it can result in inadequate protection to the materials and causes damages to the materials.

Besides than the factors listed in questionnaire, one of the respondents had specify that well manage to workers to avoid unnecessary double works is also an important method of waste minimization.

Table 4.6: Importance Index of the Methods Used to Dispose of the Waste Materials

Construction Waste Materials	Degree of Frequency					Importance Index	Overall Rank
	5	**4**	**3**	**2**	**1**		
Recycling	2	3	19	3	3	0.5867	4
Reuse	3	7	17	2	1	0.6600	3
Landfill	8	9	6	4	3	0.7000	2
Dumping	12	11	3	2	2	0.7933	1
Incineration plant	2	1	7	10	10	0.4333	5
Open air burning	0	2	4	3	21	0.3133	6

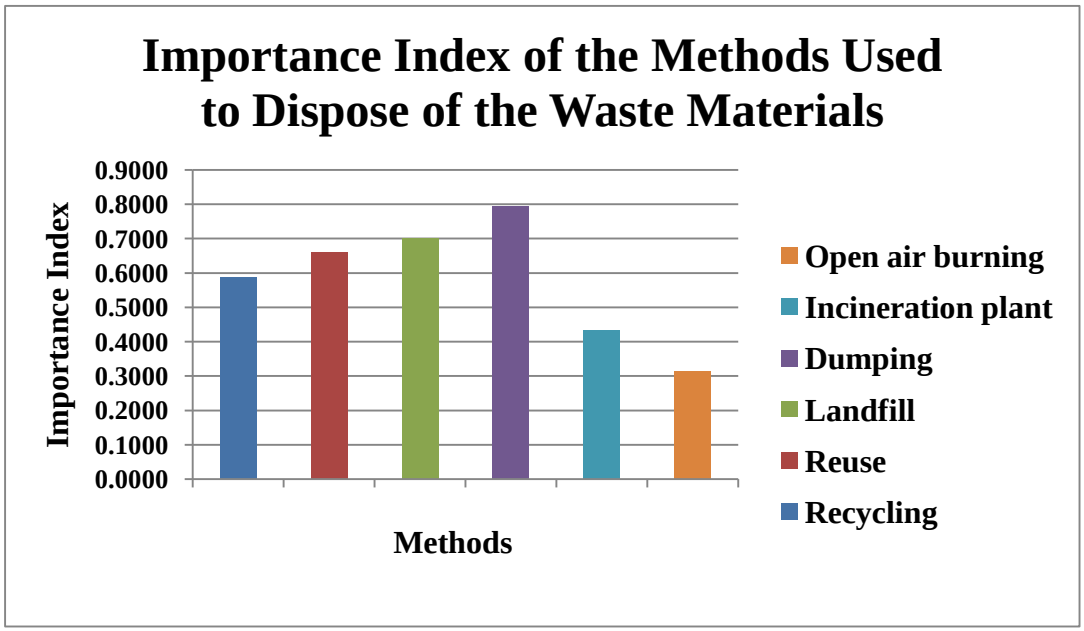


Figure 4.10: Importance Index of the Methods Used to Dispose of the Waste Materials

Table 4.6 and Figure 4.10 illustrates that the most frequent method that used to dispose of the construction waste materials is dumping which has the highest importance index at value of 0.7933 while the important index for open air burning is 0.3133 which is the lowest importance index in this group of analysis.

Open air burning the waste materials can also cause severe pollution to the environment. Besides that, the most important is that open air burning is a big crime. It is banned by law and penalty will be given for those who break the law. However, in the author's opinion, recycle and reuse are the best options to sustain and conserve resources for our future generation.

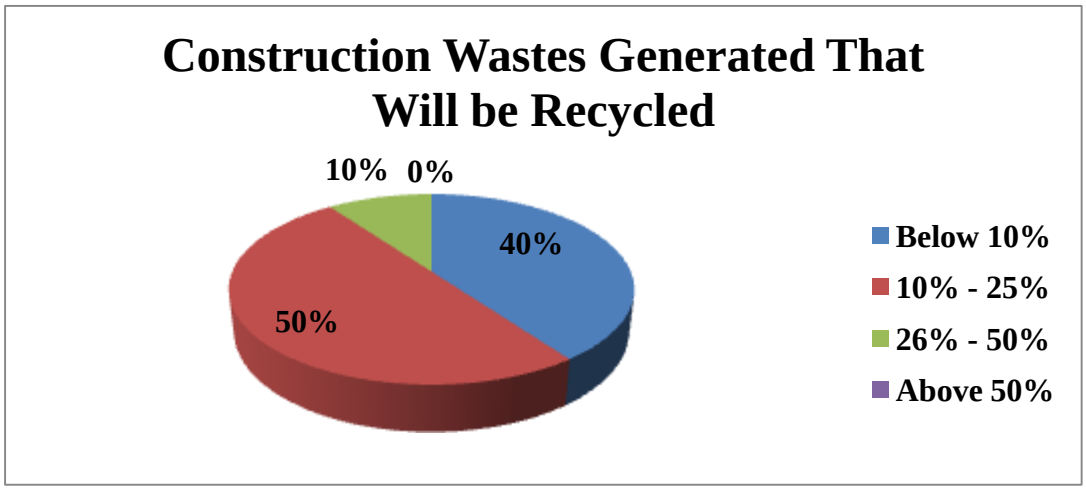


Figure 4.11: Construction Wastes Generated That Will be Recycled

Pie chart in Figure 4.11 indicates the percentages of construction waste generated that will be recycled. The result shows that 50 % of the respondents think that 10 % to 25 % of the construction wastes generated will be recycled. Apart from that, there are also a large percentage of respondents for category of below 10 %, which constitute of 40 % of the respondents. Besides that, there is no one of the respondents think that more than 50 % of the construction wastes generated will be recycled.

It may have some difficulties or factors that will affect the recycling of construction waste such as contamination, quality of waste, difficult in collection and transport and difficult in sorting, transforming and disposing. Therefore, due to those problems, majority of the respondents think that there is only small percentage of the construction waste generated will be recycled.

Table 4.7: Importance Index of the Effects of Waste Minimization by Recycling

Construction Waste Materials	Degree of Importance					Importance Index	Overall Rank
	5	4	3	2	1		
Avoid trash collection and disposal fees	4	5	16	4	1	0.6467	7
Improve organization's public image	3	12	12	2	1	0.6933	5
Make new products from old materials	6	12	4	7	1	0.7000	4
Improve the market for recycled content products	4	14	10	1	1	0.7267	2
Helps meet local and state waste reduction goals	6	8	14	0	2	0.7067	3
Increase profit	6	8	8	7	1	0.6733	6
Increase landfill life	3	6	9	9	3	0.5800	8
To reduce environmental impacts	11	12	6	1	0	0.8200	1

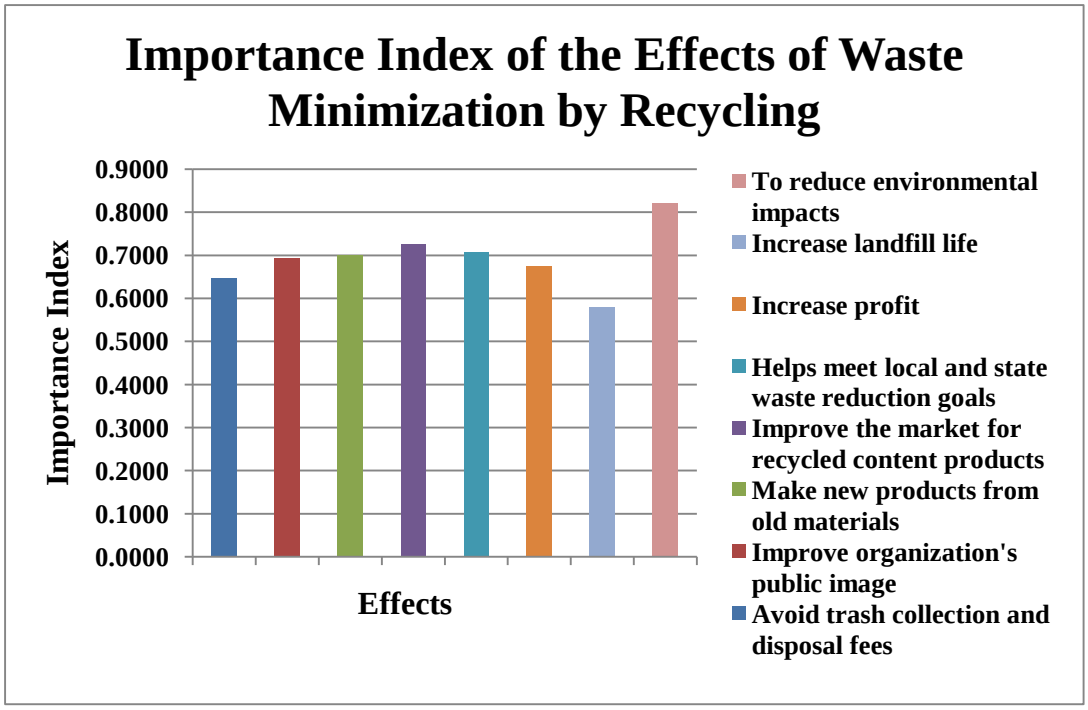


Figure 4.12: Importance Index of the Effects of Waste Minimization by Recycling

Table 4.7 and Figure 4.12 above show the importance index of the effects of waste minimization by recycling. It was found that most of the respondents think that the most important effect is to reduce environmental impacts at an importance index of 0.8200. Meanwhile, increase landfill life scores the lowest importance index which is at a value of 0.5800 only.

Nowadays, there is a large amount of construction waste is being produced by the construction sector due to the demands in implementing construction projects in Malaysia. Thus, reducing the environmental impact is an important area of concern in the implementation of the construction. It is also an important part of commitment to respecting the world.

Table 4.8: Importance Index of the Main Problems in Recycling of Construction Wastes

Construction Waste Materials	Degree of Importance					Importance Index	Overall Rank
	5	**4**	**3**	**2**	**1**		
Contamination	1	6	16	4	3	0.5867	4
Quality of waste	6	13	7	2	2	0.7267	3
Difficult in collection and transport	6	11	10	3	0	0.7333	2
Difficult in sorting, transforming and disposing	8	9	11	1	1	0.7467	1

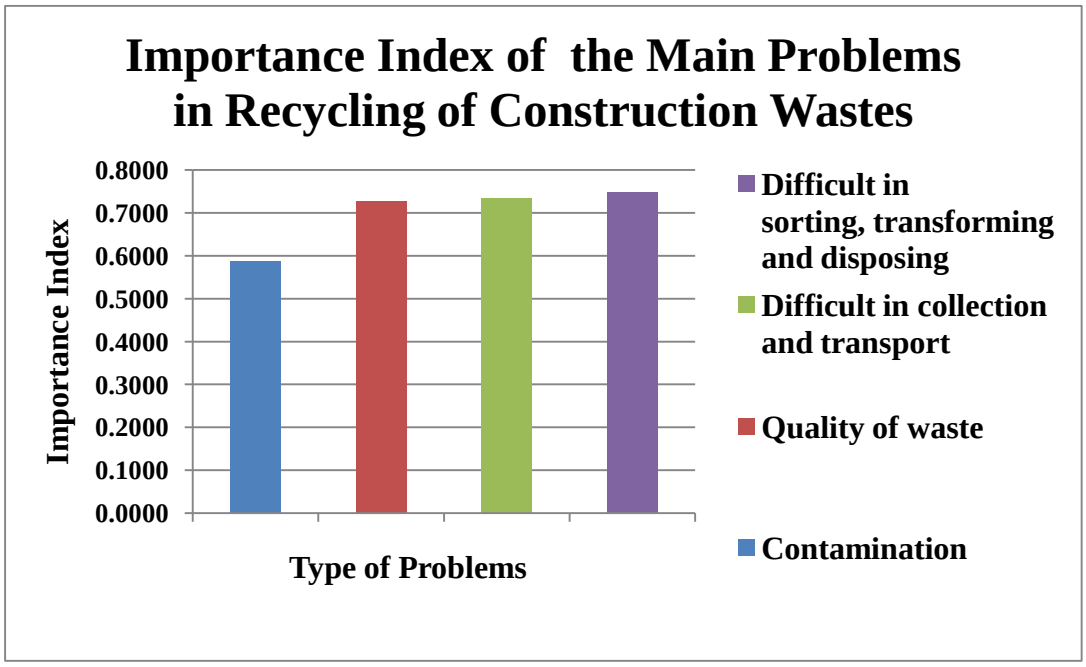


Figure 4.13: Importance Index of the Main Problems in Recycling of Construction Wastes

As the results shown in Table 4.8 and Figure 4.13 above, respondents had ranked the main problems in recycling of the construction wastes depends on the importance of the problems. Respondents had ranked that the most important main problem is difficult in sorting, transforming and disposing which at an importance index of 0.7467. This is closely followed by difficult in collection and transport and quality of waste at importance index of 0.7333 and 0.7267 respectively. While contamination scores the lowest importance index which is 0.5867.

Construction wastes such as demolition wastes that were all mixed up together will result in difficulties in sorting, transforming and disposing. Apart from that, sorting and crushing may require expensive cost in the recycling process because the processes require a lot of labour.

Besides that, there are two respondents had specified other problems other those listed in questionnaire. First, by recycling of construction wastes cannot make the profit such as transportation fees or lousy management such as wrong calculation

of concrete. Second, extra cost will be incurred where cost incurred is more than benefit returned.

Table 4.9: Importance Index of the Factors to Encourage Construction Waste Recycling

Construction Waste Materials	Degree of Importance					Importance Index	Overall Rank
	5	4	3	2	1		
Increase landfill tax to avoid indiscriminate dumping	3	5	13	5	4	0.5867	3
Use green materials	9	11	7	1	2	0.7600	1
Impose charges when the wastes exceed a certain amount	8	7	13	1	1	0.7333	2

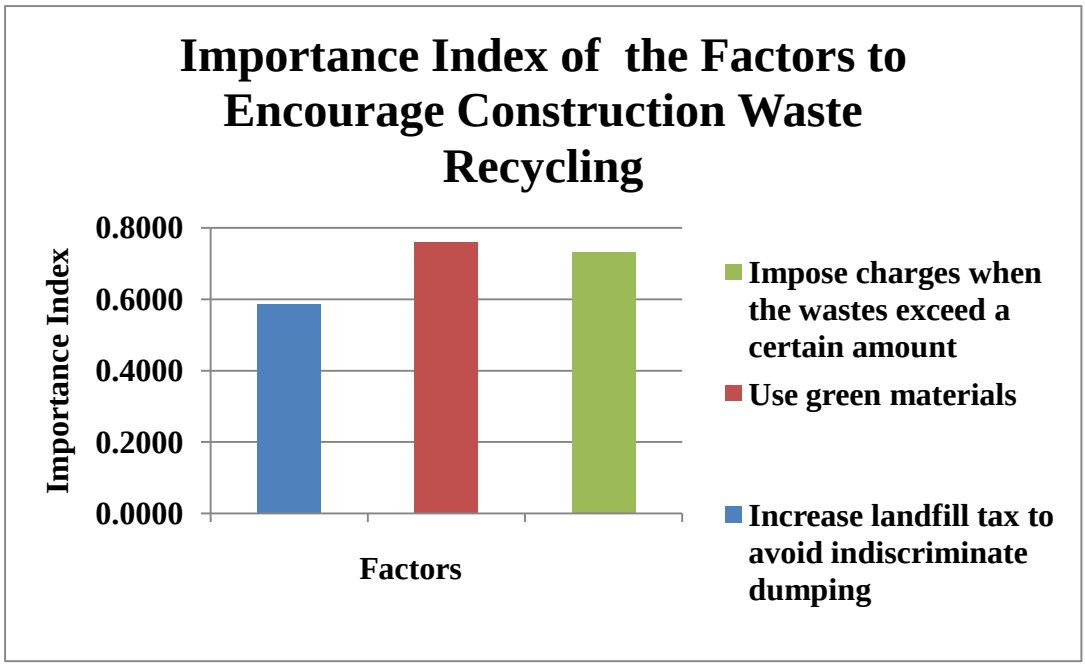


Figure 4.14: Importance Index of Factors to Encourage Construction Waste Recycling

The data are tabulated in Table 5.8 above which were obtained by construction companies depends on the importance factors that encourage construction waste recycling. Use green materials possess the highest importance index at 0.7600. This followed by impose charges when the wastes exceed a certain amount at an importance index of 0.7333. Meanwhile, the least important factor to encourage the construction waste recycling is increase landfill tax to avoid indiscriminate dumping with an importance index of 0.5867 only.

Nowadays, construction materials and building techniques have changed in the past several decades to become more energy efficient. Many new innovations are less harmful to our environment as well. Using green materials has becomes popular nowadays as it brings many advantages such as help to protect the natural environment, minimize pollution and also create a more healthy, comfortable, non-hazardous building.

Furthermore, there are some other factors that are also important to encourage construction waste recycling specified by the respondents such as workmanship and impose act by government and professional body.

4.3 Interview

There were two interviews with a project manager and a site manager was done to get a thorough and clearer picture on recycling of construction waste in Malaysia.

4.3.1 Interview with Project Manager

First interview was conducted with a project manager, Mr. Chong Chu Kok from Mega Mall Development Sdn. Bhd. who has eleven years of working experience in the construction industry at the company’s office.

According Mr. Chong, waste management is very important and it brings benefits such as reduce environmental impacts and also increase the company's profit. His company has also adopted waste management policy such as try to minimize the use of timber formwork and reuse of the construction materials. In order to tackle likely waste generated, he thinks that government should develop a programme so that it can easy to explain and educate to people of the importance of waste management.

In Mr. Chong's opinion, recycling of waste should be practiced in construction site due to construction site create a lot of construction waste and most the waste can be reuse or recycle. The benefits of construction waste recycling is it can reuse the construction material and at the same time it helps to save natural resources by reducing the use of raw material like cutting the trees.

Furthermore, the factors which caused generation of construction waste such as design, procurement, materials handling, construction or renovation and demolition can cause the quantity of waste increase or decrease. The most important factor is the design due to people is managed or plans to order the material according to the design. Moreover, Mr. Chong says that that the best option that can be used to dispose of construction waste materials is to reduce the construction waste materials by using the alternative material to replace those materials that cannot be reuse or recycle.

Apart from that, there are also some difficulties in disposal of the construction waste such as there is no proper channel to recycle or reuse the huge quantity of construction wasted created. Besides that, the process may take a lot of time or costly if compare with burning or bury the construction wastes. Moreover, the recycling field in Malaysia is only running in small scheme. The construction wastes are normally involved in big scheme and therefore it needs a lot of the resources such as human, transport and machinery to enhance the works.

In addition, Mr. Chong has recommended that government must enforce have sufficient law enforcement. Penalty or fines shall be imposed on those who do not

dispose the construction waste properly. Meanwhile, the government can also encourage more people to practice waste management by reducing a tax.

Lastly, Mr. Chong thinks that the Environmental Quality Act in Malaysia on construction wastes is insufficient. The enforcement is not strike enough. In his opinion, the enforcement must strike and work in twenty four hours to reduce cse such as open air burning.

4.3.1.1 Critical Review of the Interview with Project Manager

Mr. Chong's company emphasizes on enhancing environment by adopting waste management policy such as reduce the use of timber formwork and reuse of the construction materials has been adopted by his company in order to achieve environmental friendly as well as reducing the environmental impacts, conserving space in landfill. Besides that, reusing or recycling waste materials can have significant and long-term benefits which includes reduce project costs, helps contractors and building owners comply with state and local policies regarding construction wastes and also boosting the public image of companies and organizations that recycle.

Mr. Chong had expressed some hardships which most of the construction players in Malaysia facing when they are dealing with the disposal of construction waste. The author agreed with Mr. Chong that there is no proper channel provided to enable the recycling of large quantity of construction waste. In order to cope with this particular problem, the local authorities should implement some workable solutions and channels to enable and encourage the recycling of construction waste. Further, recycling field in Malaysia is merely running in small scheme, there is a need to expand it. Although recycling process is going to cost quite a large sum of money, it is worth to adopt and continue with it as it will bring a lot of benefits which have been indicated earlier.

4.3.2 Interview with Site Manager

Second interview was conducted with a site manager, Mr. Goh Chin Huat from Kenforce Construction Sdn. Bhd. who has 10 years of experience in the construction industry at the site office.

According to Mr. Goh, waste management is a very important issue today. The construction industry in Malaysia is developing rapidly and it is expected that it would be elevated in growth in the future. Thus, a large amount of construction waste will be generated and all these wastes must be handled and managed proper. If the construction waste not properly handled, it may consume a large amount of land acquisition fees or garbage fees and also result in serious environmental pollution.

Besides that, Mr. Goh says that construction companies should properly deal with the construction waste and waste management policy should be adopted to handle the waste generated. Mr. Goh thinks that the government should develop a programme to tackle the waste generated. The government can and must do more to educate construction parties in proper waste management so that they can have better knowledge and increase awareness about waste management issue.

In Mr. Goh's opinion, recycling should be practice in construction site in order to maximise material usage and minimise waste generation. Construction waste recycling can brings advantages such as increase profits and reduce environmental impacts. Recycling can be enforced by government by developing programmes to increase knowledge and create recycling awareness of the construction parties.

Moreover, Mr. Goh says that design is be the most important factors that caused construction waste generation. For example, modification to design or the client's additional works will cause change orders of the materials and may result in over-ordering of the materials. Mr. Goh thinks that reuse and recycle is the best option of waste disposal. Some of the construction waste materials can be reused on-site. Total disposal costs can be reduced by reuse and recycling the waste materials. For example, old brick, broken blocks and other masonry rubble can be used as backfill along foundation walls. Other than that, lumber is one of the most commonly

wastes at construction sites. However, it is easy to recycle even if warped or water damaged.

However, there are some difficulties in recycling of construction waste. According to Mr. Goh, the major problems are difficulty in collection and high cost may incur due to the collection and transportation. Furthermore, it also requires labours to collect and transport the waste.

Lastly, Mr. Goh thinks that the Environmental Quality Act in Malaysia on construction wastes is satisfied. However, it still has the room for improvement by considering more recycle agents and introducing certain method to ensure monetary return in order to generate more profits.

4.3.2.1 Critical Review of the Interview with Site Manager

The author agreed with Mr. Goh's opinion that there is a need to improve the Environmental Quality Act in Malaysia. Environmental Quality Act is an act related to the prevention, control of pollution and enhancement of the environment. Recycling agents is not sufficient enough to cope with the large quantities of construction waste generated. Therefore it must be increased and proper channel to dispose waste should be provided.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

Summary finding of the survey results which were done earlier from previous chapter will be discussed in this chapter. This chapter also discusses the conclusion for the overall research based on the objectives. Besides that, there are some recommendations on the construction waste recycling and further research.

5.2 Summary of Findings

a) Types of construction projects
   - Type of construction projects which has been carried out mostly by the respondents is high rise buildings. Besides that, commercial and housing estates also occupied a large percentage in the data obtained.

b) Estimated weight of waste generated per say for a project
   - It was found that the construction waste generated per day for a project is 1 to 5 tonnes per day.

c) Waste materials generated on site
   - Wood/timber is the most commonly construction waste generated on site. Besides that, brick/block and masonry/mortar also contributed to the major

part of the construction waste generated on site while asphalt is the waste materials that is seldom generated.

d) Waste materials that are frequently recycled
   - Respondents ranked that metal as the waste materials that are frequently recycled. Metals such as steel and aluminium which have high value of being recovery or recycling are usually collect and placed properly for future use or recycle in other construction project. On the other hand, concrete is seldom to be recycled.

e) Recycling costs of waste materials
   - Respondents ranked that metal as the waste material that has high recycling cost. The metals sector has traditionally been one of the most profitable recycling industries although high recycling cost is required. On the other hand, cardboard has lowest recycling cost.

f) Factors leading to the production of construction wastes
   - Respondents ranked that demolition is the main factor which causes the production of construction waste. It is agreed by respondents that procurement is seldom led to the production of the construction wastes.

g) Frequency of the construction waste materials on site sorting
   - It was found that the construction waste generated per day for a project is 1 to 5 tonnes per day.

h) Methods of waste minimization during construction works
   - "Careful evaluation of materials so that over-ordering and site wastage is reduced" is the best practice to reduce waste during construction works. Waste minimization is seldom practice by reducing the amount of packaging amount.

i) Methods used to dispose of the waste materials
   - Respondents ranked that in order to dispose the waste materials, the construction workers tend to dump the wastes at most of the times. On the

other hand, open air burning to eliminate waste material is seldom to be carried out.

j) Construction wastes generated that will be recycled
   - It was found that 10 % to 25 % of the wastes materials generated will be recycled. It seems that there is less demand of contractor sector in reuse or recycle of the waste materials.

k) Effects of waste minimization by recycling
   - It is agreed by the respondents that main advantages of recycling is help to reduce environmental impacts. Conversely, the respondents were in the opinion that minimizing the waste by recycling did not contribute much on the increase landfill life.

l) Main problems in recycling of construction wastes
   - Difficult in sorting, transforming and disposing the waste materials are the main problems in construction waste recycling. Whereas the problem of contamination is not much to be concerned in the recycling of construction wastes

m) Factors to encourage construction waste recycling
   - Respondents ranked that “use the green material” as the main factor to encourage construction waste recycling. While more respondents considered that the action to increase landfill tax to avoid indiscriminate dumping is not a very encouraging factor to motivate them to recycle the construction waste

5.3 Conclusion

The aim of this study is to investigate the waste recycling in the construction industry. It can be concluded that generally the construction personnel are aware of the construction waste. However, the practice of recycling the construction waste is still not commonly adopted. The objectives stated in chapter one which are to identify the

construction materials that can be recycled, to identify the methods used to dispose of the construction waste in Malaysia and to identify the advantages of recycling the construction waste have been met.

5.3.1 Construction Materials That Can Be Recycled

From the analysis of the collected data, the commonly recycled construction wastes are arranged in the order of importance of recycling are as shown below:

1) Metals
2) Wood / Timber
3) Brick / Block
4) Cardboard
5) Drywall / Wallboard
6) Masonry / Mortar
7) Glass
8) Asphalt
9) Concrete

Results from the research shows that metals are the most frequently recycled. Nowadays, recycled steel is used extensively throughout the world. The recyclability of metals enables metal construction products to be included in listings for “green” or sustainable building materials.

Besides that, wood/timber which possesses second highest importance index is also one of the frequently recycled materials. By recycling wood waste, there are a number of benefits which includes preservation of natural resources and reduced environmental impacts. Furthermore, cost savings can be achieved from reduced landfill disposal fees. Recyclable wastes such as wood/timber can be converted into site hoarding and workers’ quarters. Furthermore, wood from formworks or roof trusses may also be able to be reused in their original functions.

On the other hands, the material that seldom recycled is concrete. By recycling concrete, energy consumption and related emissions can be reduced meanwhile reducing the environment impact and also reducing the amount of waste sent to landfills. Although recycling concrete offers many benefits, there are still many difficulties in recycling the concrete which will limit the benefits of recycling in some areas. Many recycling centres only accept concrete that free of rebar, steel and other contaminants to make the process of recycling concrete easier. Labours cost may increase due to labour is required to remove the steel which subsequently result in higher recycling cost required and time consuming. Besides that, recycled concrete has lesser strength than concrete manufactured from raw materials. This may limit the applications for which recycled concrete can be safely used.

5.3.2 Methods Used to Dispose of the Construction Waste in Malaysia

From the analysis results, the methods used to dispose of the construction waste in Malaysia are arranged in the order of importance as shown below:

1) Dumping
2) Landfill
3) Reuse
4) Recycling
5) Incineration plant
6) Open air burning

Results from the research shows that the most frequent method that used to dispose of the construction waste materials is dumping. Dumping is the most popular method as it is cost-efficient and fast. Other than dumping, landfill is the next popular option. There are also many construction waste goes into landfills which result in increasing the burden on landfill loading and operation.

Although reuse or recycling is the most environmentally option, but it is unpopular due to time consuming and cost incurred for recycling process. Recycling also has constraints which makes it an unpopular option among contractors in

disposing the construction wastes. The most important factor will be the difficulty in sorting, transforming and disposing of the waste. Recycling may take some time due to difficulties in separation of wastes material. Moreover, there is some additional cost involved in recycling construction material waste such as transportation costs and labour costs.

Open air burning the waste materials can also cause severe air pollution to the environment resulted from large amounts of carbon dioxide and other gases in the air that released from the burning process. Besides that, the most important is that open air burning is a big crime. It is banned by law and penalty will be given for those who break the law.

5.3.3 Advantages of Recycling the Construction Waste

Results from the research shows the advantages of recycling the construction waste are as shown below:

a) Avoid trash collection and disposal fees
b) Improve organization's public image
c) Make new products from old materials
d) Improve the market for recycled content products
e) Helps meet local and state waste reduction goals
f) Increase profit
g) Increase landfill life
h) To reduce environmental impacts

From the analysis, the main advantage of recycling the construction waste is to reduce environmental impacts. It is expected that the construction wastes will be increase in the future due to the demands in implementing construction projects in Malaysia, a developing country. Thus, reducing the environmental impact is an important area of concern in the implementation of the construction. Nowadays, people around the world have become increasingly aware of and concerned about the environmental issues. Many construction companies had adopted waste management

policy. Increase energy efficiency, reduce construction waste and reduce any polluting emissions will increasingly save the company money in the long run and often helps to improve the company's public image.

Improve the market for recycled content products have scored the second highest important index. By recycling the wastes, it diverts waste from landfill and can generate a market for recycled content products and save money by reducing cost to dispose it. By improving the market for recycled content products, it can also displace the need for new materials. However, recycled materials require reprocessing such as crushing, chipping or melting. All these processes may also require energy and result in waste and emissions. For there to be an environmental advantage, the impacts of the reprocessing need to be less than the impacts of using new.

On the other hand, increase landfill life scores the lowest important index. This may due to the fact that land in our country is relatively cheap and there is no volume based free system installed for wastes. Although recycling can increase life span of a landfill and preserve landfill space, landfill has also some disadvantages that are associated with it. Landfill takes up lots of land and can cause damage to animal and plant habitats. Furthermore, it can also lead to environmental pollution such as releasing dangerous gases that may cause air pollution and increase the chances of global warming.

5.4 Recommendations

The issue waste management has not been adequately understood and addressed in the construction industry in Malaysia. One of the reasons for the failure of recycling programmes is lack of understanding and the low level of environmental awareness. There are several recommendations to encourage waste recycling in the construction industry.

Firstly, programmes can be developed in order to create awareness regarding the environment and the importance of recycling the construction waste and encourage the construction parties to adopt waste management policy. Through the awareness by the construction personnel on how it is important of waste minimization and recycling, the waste generated will be greatly reduced.

Other than that, a programme that recognizes developers who are selling environmentally preferable products should be introduced. Developers who are selling environmentally preferable products should be given opportunities to promote their products. The introduction of such programmes will encourage developers to produce environmentally friendly products. Government plays an important role in promoting construction waste recycling and motivating the construction parties to join recycling programme with education and promotion within the construction sector.

In addition, policy statement for construction wastes should be introduced at the local level. Government should incorporate policy statements for construction waste management in the proposed of solid waste management policy. Policies should be formulated which ensure that recognized environmental and quality standards are met in all categories of construction projects.

Some recommendations for further study on waste recycling in the construction industry are as shown below:

a) Economic feasibility of recycling construction waste.
b) Explore and investigate a more effective and efficient recycling process.
c) Strategies for successful construction and demolition waste recycling.
d) Studies on how the recycling process can be carry out in the local construction environment.

Moreover, the size of the sampling should be broader and wider types of construction materials can be included in order to obtain more accurate findings and detailed survey on the waste control and management practice. More questionnaires are recommended to be sent to get more return in order to more accurate data.

In conclusion, the data obtained from the research shows that the importance of waste recycling in the construction industry. It is hoped that the future construction sector will show more concern on construction waste recycling in order to obtain sustainable development.

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APPENDICES

APPENDIX A: Statement of Learning Outcome

Through this research, the author has observed the current situation of waste management and how recycling has been practices so far in the local construction industry. The author has realized that there is a need to aware the construction parties to have a proper management in reducing the construction waste generated.

Besides that, interviewing skill has learned by the author. The author learned how to interview a person with the right techniques in conducting interview. Other than that, communication skill has been improved through the interviews with professional construction parties. A good communication is being aware of the real effect your speech has on other people, and not the effect you imagine it has.

APPENDIX B: Sample of Interview Questions

APPENDIX C: Sample of Survey Questionnaire

APPENDIX D: Sample Returned Questionnaires

APPENDIX E: Record of Supervision/Meeting

APPENDIX F: Project Definition Document