DETERMINING WASTE GENERATION FACTORS IN KLANG VALLEY REFURBISHMENT PROJECTS

CHAI KOK LIONG

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ABSTRACT

Construction wastes become serious environmental problems in many countries. In Malaysian construction industry, the waste generation is so significance to the cost of construction project. Waste can be produced because of variety factors. Within the lifecycle of buildings, waste could be generated in the process of during the construction and demolition phases. This will directly affect to the cost and it will become a burden to clients due to bear the costs of waste eventually.

The aim of this study is to find out the effectiveness of waste implementation methods in order to reduce the actual construction cost. The factors that cause waste generation will be study in this research. Research in waste implementations will be study in this research as well in order to provide greater scenario of waste minimisation in Malaysia construction industry. After that, the significance of waste implementations will be identified from data analysis. Questionnaires will be prepared and distribute to the construction sector people to identify the real scenario of waste minimisation in construction industry of Malaysia. The methodologies used are by survey. Through survey and analysis processes, the objectives of this research will be discovered and then the researcher could able to recommend and suggest advices on waste minimisation.

The recommendation listed out and discussed will enhance the waste minimization for the construction industry and hopefully the reader of this research could realise the importance of waste minimization

ABSTRAK

Bahan-bahan buangan pembinaan menjadi masalah alam sekitar yang serius dalam kebanyakan negara. Dalam industri pembinaan Malaysia, penghasilan buangan adalah supaya kepentingan untuk kos projek pembinaan. Sisa telah dapat melahirkan disebabkan oleh pelbagai faktor. Dalam kitaran bangunan, sisa boleh dihasilkan dalam proses semasa pembinaan dan fasa-fasa perobohan. Ini akan memberi kesan secara langsung untuk kos dan ia akan menjadi satu beban akibat menanggung kos sisa.

Tujuan kajian ini adalah bagi mengetahui keberkesanan kaedah-kaedah pengurusan sisa dengan tujuan mengurangkan kos pembinaan yang terlibat. Punca penjanaan sisa itu akan menjadi kajian dalam penyelidikan ini. Penyelidikan dalam pengurusan sisa akan menjadi kajian dalam penyelidikan ini untuk tujuan menyediakan senario yang lebih jelas tentang pengurangan sisa di industri pembinaan dalam Malaysia. Selepas itu, punca dan faktor penjanaan sisa dapat dikenal pasti daripada analisis data. Soal selidik akan disediakan dan mengagihkan untuk orang sektor pembinaan bagi mengenal pasti senario sebenar pengurangan sisa dalam industri pembinaan Malaysia. Methodology yang digunakan adalah kaji selidik dan proses analisis. Objektif-objektif bagi penyelidikan ini akan ditemui dan kemudian penyelidik boleh dapat mencadangkan dan menasihatkan tentang pengurangan sisa.

Semoga kajian in akan meningkatkan pengurangan sisa untuk industri pembinaan dan semoga pembaca penyelidikan sedar tentang kepentingan dalam pengurusan sisa.

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CHAPTER 1

1.1 Introduction

Waste produced in the construction sector has become a critical issue in terms of cost performance, as well as, the negative impact that results on the natural environment. This is because waste occurs in the lifecycle of a building; the construction stage, maintenance, renovation, refurbishment, restoration and demolition phases. It has become a serious environmental problem in both developed and developing countries. For example, in the United Kingdom, Esin & Cosgun (2007) had reported that a typical landfill in the UK consists of over 50% construction waste. Pollution occurs in most construction activities that require electricity, especially during operations. Mainly, waste transportation and waste composition time are what contribute to air and water pollutions in landfill areas. Firstly, research from Holm (1998) and Katz & Baum (2011) had demonstrated that as much as 60% of materials ordered become waste, and only 40% are used in construction work. Secondly, the typical wastage of materials in the UK construction industry is recorded as being 10 to 15% (McGrath & Anderson, 2000). Similarly, a study by DETR (2000a) had estimated that around 70 million tons of construction waste is produced per annum due to various materials used in the construction sector. The entire research had further found evidence which showed that landfills around the world consist of large portions of underutilised materials from the construction industry, proving that the problem does exist. Raising awareness for waste minimisation of construction projects is a key success factor in cost efficiency and the creation of environmentally friendly development.

Li, Yang & Liqi (2010) had noted that materials and components dismantled from buildings have high potential to be reused or recycled. With appropriate handling and managing of these wastes, a sustainable environment and cost efficient projects can be achieved. Egan (1998) stated that the only way of achieving better quality and efficiency in the construction industry is by reducing the waste generation in all stages of construction (procurement, material handling, storage, site management, etc.). The result will lead to lower construction cost driven by the importance of construction waste management and material utilisation.

Material waste does not only have a negative impact on the environment, but also adds cost to construction projects. The additional cost of waste is rather difficult to estimate since different groups define waste in their own ways. Material waste has an impact on the environment which will indirectly increase the cost of construction due to government imposed taxes on pollution and waste. In Malaysia, the government taxes are negligible in amount, making them low in significance.

The cost of waste will then transfer to the end user and the finished product will sell at a higher price with little profit, making it harder to compete with others in such a competitive environment (Macozoma, 2002). Teo & Loosemore (2001) estimated that contractors with 10% or higher waste are disadvantaged in tendering. This is because the cost of waste is part of the overall cost in the tendered sum. Additional materials, delays, extra cleaning work, left over debris clearing and head count costs will reduce the profit for contractors (Sa'adi & Ismail, 2015; Skoyles & Skoyles, 1987). Managing waste can increase the competitiveness of contractors by lowering cost; prompting better publicity for the company. However, most contractors do not pay much attention to waste or the implementation of it (Fishbein, 2009; Lam, 1997). This is because they believe finishing or completing the project earlier is better in regards to cost saving than managing waste (Poon et al., 2004). Besides cost performances, enhanced construction operations through

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improved safety, health and time preservation may be achieved by the managing of waste (Chan & Ma, 1998; Skoyles & Skoyles, 1987).

Alwi et al. (2002) stated that the overall performances and productivities in construction could be affected by construction waste. The current literature regarding solid waste management is only focused on three issues:

(i) the applicability and viability of user charges in solid waste management,

(ii) the analysis of which are the best tools to change the scale of wrapping in the waste stream, and

(iii) the advantages and value of using those instruments to speed up waste reduction and recycling (Brisson, 1993; Dinan, 1991).

According to Formoso et al. (1999), waste is classified as *"any losses produced by activities that generate direct or indirect costs but do not add any value to the product".* Whereas, Koskela (1992) stated that construction waste is in *"relation to time delays, quality costs, lack of safety, rework, unnecessary transportation trips, long distance, improper choice of management, methods or equipment and poor constructability*." Hassan et al. (1998) had further derived their analyses of material waste by referring to data from the Central and Southern regions of Malaysia. The results demonstrated that 36.73% of waste was from household waste, 28.34% from industrial and construction waste, and the remaining 34.93% was from other sources such as markets, commercial waste, institutional waste, landscaping waste and street sweeping waste. From statistics, Malaysia has a large number of construction waste disposed in landfills despite taking the timing of the sources acquired.

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Even existing processes of construction debris flow from the category of generation, waste, transitional and dumping, the quantum of waste minimisation, as well as, reuse or recycle data are not readily available in Malaysia's construction industry. However, as commonly known, and referring to local authorities in the said regions, waste generation is rapidly increasing annually in Kuala Lumpur. Proper waste management should be implemented to reduce waste. Moreover, the construction sector must be responsible when producing various waste through constructions; especially from major infrastructures, commercial, housing and other highly demanded construction activities. The number of waste variety is determined by characteristics, such as the phases in construction. Different types of construction work and practices on site must be managed according to regulations. Failing to do so would lead to abuses by some parties since they may dump debris into lakes, jungles, rivers, ravines and vacant lands. As a result, erosion may occur, as well as, the contamination of water, increased pests, fire hazards and the spoiling of the aesthetic view of nature.

Pollution occurs when excessive waste produced by the construction industry is faster than the biodegradation rate. Thus, waste minimisation in Malaysia's construction sector is crucial in keeping the natural environment in good shape. One way to minimise would be implementing refurbishment projects instead of new construction and demolition. The researcher focused on investigating the relations that exist between waste minimisation and the total cost of refurbishment projects. Attention was given to factors that influence the waste variable in refurbishment works. Thus, waste in refurbishment will be reduced; hence, the total cost of construction will decrease. This paper was based on a questionnaire that involved refurbishment projects carried out in Klang Valley, Malaysia from years 2012 to 2014. The research also included the economic feasibility of waste minimisation by recycling construction waste materials.

Waste generation from the construction industry in Malaysia relatively contributes to the overall national waste burden. Thus, the awareness towards waste minimisation for construction has become a vital issue (Begum, Siwar, Pereira & Jaafar, 2006).

1.2 Refurbishment Projects

Refurbishment is widely acknowledged as upgrading, work repairing, renovating, alternating, conversing, extension and modernisation of a building; not including periodical building maintenance and cleaning work (Quah, 1988). No building in the world can have an infinite life span or economic life, all buildings undergo deterioration processes until they become unfit or fail to perform as required. The building lifecycle include design, construction, testing and commissioning, operating, maintenance, restoration, refurbishment, and lastly, demolition. Near the end of the building cycle, refurbishment/demolition/redevelopment options will be considered. Demolition seems to be a very famous alternative in renewing building properties since it is known to be the easiest way. Due to its simplicity, buildings have been demolished prematurely, based on economic factors (Langston et al., 2007). Most developers and owners choose to demolish existing buildings to maximise the plot ratio. The reason is because the buildings are old, and only limited alternative designs can be considered. In addition, there is the mindset that refurbishments cost more compared to new construction (Ball, 2002; Latham, 2000; de Valence, 2004; Langston et al., 2007). Fortunately, revulsion against the demolition of buildings for redevelopment or improving building conditions is so strong nowadays.

Despite the demolition pros; the disadvantages include time consumption and being harmful to the environment. Most dismantled materials from demolitions are hard to recycle or reuse. Demolitions take longer periods in acquiring approval for disposing debris; this consists of longer processes of demolition and removing debris from site in

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comparison to refurbishment works. Continuous high requests for modern design and sustainability of building performances will lead to the decision for demolition by the asset owner; especially since there are limited vacancies in major big cities.

Demolition and refurbishment are always the two options for the public, but historically, refurbishment is more friendly and fair to all parties involved in the decision-making. Demolition is not a practical way unless it is supported by strong reasons. In several professional researches, it was found that addressing a refurbishment process will greatly reduce the building cycle cost and waste. In recent years, refurbishment works have become a common choice for properties that have reached the end of their life cycles. It will eventually contribute to enhanced building performances, as well as, sustainability compared to demolition and reconstruction (Bullen & Love, 2011). An extra bonus of refurbishment work would be less negative environmental impacts. This is because waste generated from demolitions are more significant than refurbishment works. Refurbishment is widely acknowledged as upgrading, work repairing, renovating, alternating, conversing, extension and modernisation of a building; not including periodical building maintenance and cleaning work (Quah, 1988). Research from Aikivuori (1996) demonstrated that the main reason behind refurbishment works is due to building deterioration and obsolescence. From observations, dozens of pre-war buildings were refurbished instead of demolished and reconstructed. This was due to the awareness that building life can excessively increase to 80 years (Shah & Kumar, 2005b). By knowing the extended life span of buildings, it has become an alternative solution for clients to redevelop the area without conducting much demolition works.

Refurbishment has become more than an alternative when a building has failed to perform its required use or has come to the end of its life span. Normally, the refurbishment

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process is dominated by building performance degradation and falling into disuse such as changes in functionality, economy, financial purpose, heritage reserves and changes in the building's physical form (Aikivuori, 1996). Presumably, refurbishment works carried out in Malaysia are influenced by these same factors. Several commercial buildings at Jalan Alor, Jalan Chow Kit and Jalan H.S Lee have accomplished refurbishment works because of investment value. Return of investment is usually higher in buildings that have been refurbished due to an improvement of the building's aesthetic view. However, some owners are not ready to offset higher rentals simply because of an improved aesthetic view and long term energy bill reduction. Therefore, additional cost comparisons between refurbishment and surrounding asset value must be done in order to assure the owner's investment, instead of only providing a reason for better energy efficiency (Ellison et al., 2007). Besides that, in alignment with the government's vision for 2020, the social image of Kuala Lumpur's City Centre to be classified as a world class city has given rise to blooming refurbishment projects in Malaysia. Likewise, Flanagan et al. (1989) had stated that building refurbishment originates from building degradation and their fall into disuse, such as aging, difference in its original use, publicity, image and regulation.

Mansfield (2001) had quoted more than 20 descriptions that are currently used to relate to the endeavour of remedying the effects of building devaluation for refurbishment. Generally, the decision to refurbish an asset is to discover that the building is nearing the end of its life cycle. The main reason to refurbish is to prolong the value of an existing property by providing cost saving options for redevelopment (Markus, 1979), and improving the aesthetics of the existing building (Adair et al., 2003).

Research in UK had indicated the sustainability advantages of building refurbishment to differentiate with demolition and reconstruction (Anderson & Mills, 2002). Balaras

(2002) concluded that the growth of refurbishment and retrofitting of property is mainly due to the hunger for better sustainable building exercises all over the world. In the recommendation for a sustainable environment, building cost and design limitations are cumulated to result in restoration, an economically captivating substitution to demolition and reconstitution; especially in city centre sites. Most refurbishment activities produce solid wastes that are generally lower than redeveloping a given floor area.

It is often predictable that refurbishment would enhance the market value of old and abandoned buildings because it restores and improves the physical building's condition. In the last four decades, awareness of functional energy in a property has grown tremendously, resulting in energy improvements through refurbishment projects; an option that provides significant savings in cost (Brown, 2006).

Refurbishment works take place by the growth in building renovation projects, extensions and projects featuring major repair works. Awareness of resource-efficient and environmentally sound buildings create an opportunity for the refurbishment of existing and ageing buildings by taking cost-effective measures, similar to building renovations, restoring them to good conditions. The primary purpose of refurbishment is to protect and retain the architectural heritage, which can also be financially attractive compared to demolishing and reconstructing again. The total cost of building refurbishment is much less compared to demolition, even for high investment retrofit and redevelopment. In view of sustainability concept and theory, it is logical to refurbish and renew aging properties. A few journalists have highly recommended that the market should not further build new properties and premises, restricting the world from improving current properties, qualities and durability (Kholer, 1999). For other circumstances, new developments should be constructed in a sustainable way.

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According to Hamilton (2003), many buildings are wrongly used in Malaysia. This phenomenon will result in buildings to become rapidly dilapidated. In addition, improper maintenance will lead to building deterioration, causing the rate of wear and tear to also increase. Even though there are numerous factors that drive the growth of refurbishment works, there are also factors that prevent building owners from taking the option of either changing the old building to reconstruct a brand new one in a different location or refurbish the property.

The owners of aged buildings are sometimes in a disagreement. There are a few reasons to this argument. Firstly, there is the hidden cost of refurbishment that is not explained or brought to the attention of the owner. Some of the hidden elements, such as human flow control in an existing building and notices to existing occupants, are so costly that it halts the decision for refurbishment. Secondly, the owners are not comfortable with the entire activity of a refurbishment project. Some of them have never been involved in the refurbishment process and lack the cost and quality information that should be given by contractors. This deters owners from deciding whether to refurbish their buildings. Thirdly, the owner may not know exactly how refurbishment will benefit the building's market price. According to Kohler & Yang (2007), the rate of refurbishment works is not purely determined by physical deterioration, but by change in uses and required expectations. If the feedback to an alteration is not achievable or convincing, turnover of occupancy will be higher due to increased unhappiness of occupants (Ellison & Sayce, 2007). This will result in lower sustainability of the building due to greater vacancy rates.

Nevertheless, when refurbishment is taken as an alternative, contribution factors will result, such as the following. During the economic recession from 1997 to 1999 and 2009, cost-effectiveness became the main element in every sector, including construction. As a result, the growth of new construction projects decreased due to the rising cost of materials, transportation and resources. This encouraged building owners to opt for utilising available properties (Douglas, 2002). This also provided a possibility to revive old properties and increase building life spans with minimum cost. New constructions were put on hold due to the recession, and the government had to cut down on expenditure; this provided the opportunity for building owners to upgrade their current buildings by refurbishment instead of constructing new buildings. Furthermore, expensive land prices in the city centre or developed areas had resulted in the limitation of land for new development. These strategic areas are normally occupied by people and are difficult to acquire. Thus, refurbishment works are considered as the best option compared to other alternatives.

Likewise, Aikivuori (1996) pointed out that the major causes of refurbishment are building degradation and change of its use. Property degradation is normally caused by dampness and ground movements (Addleson & Rice, 1991). Lamentably, each property faces the same issues (Douglas, 2004). The state or condition of being slightly wet causes moisture, and this leads to corrosion on the reinforcement bar. Vegetation grows on the walls (especially on the apron of the building) and rot sets in timber elements. Soil movements would lead to hair line-cracks, as well as, major cracking on the building structure. Moreover, leakage may occur, resulting in dampness within the building if the crack line is serious.

Obsolescence means something no longer in use, that is imperfect or slightly undeveloped. Old buildings that were constructed in the 1970s and 1980s have insufficient space for additional mechanical or electrical service routes. Generally, technological development will cause the existing property stocks to become outdated.

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The growth rate of technological development is always perpendicular to the rate of building obsolescence. Desperation for refurbishment of existing stocks to become in line with modern electronic and mechanical systems contribute to the growth of refurbishment works. Modern building automation systems require adequate space in their service layout. This is important for buildings that planned for business organisations to provide better building equipment, sufficient working space and appropriate working environment to enhance the working output. Likewise, Kincaid (2003) stated that different eras of information technology have different functional use, as well as, different requests for properties from the market. With current advancements in computer technology, long distance communication is no longer an issue, everything goes online via internet. Hence, premises that fulfil the needs of modern equipment create a high demand for refurbishment works.

Regardless of the above-mentioned contributions for reasons of selecting refurbishment in Malaysia, as Quah (1988) had stated, the refurbishment process is much more unpredictable compared to normal construction processes since it consists of numerous characteristics. Each refurbishment project is unique, and the risk of each is always different. The disadvantages of refurbishment projects always come with greater total cost and longer time to complete. Factors that drive these disadvantages are due to delays of design information, different awarding packages because of complexities of refurbishment flow and inconsistency in final decisions (Rahmat, 1997). Although data on the presentation of refurbishment projects in Malaysia still carry a lot of dispute, more papers to reduce the poor project performance of refurbishment projects are needed. In any case, refurbishment is still a better option for redeveloping old buildings.

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Aikivuori (1996) had stated that commencement of refurbishment projects is most likely due to defects and failures of the structure, or pre-planned forecasting rate of deterioration. Furthermore, she also identified the range of refurbishment types, which are:

a) Corrective refurbishment
b) Altering refurbishment
c) Optimising refurbishment
d) Pleasure refurbishment
e) Opportunity refurbishment

Refurbishment seems to be a better alternative to encounter the environmental performance as new products were built with lesser impact to environmental performance codes. Refurbishment has been considered more frequently by owners when they plan to reconstruct or redevelop the deteriorated building.

In this research, the researcher had studied waste management in construction and refurbishment projects. Literature reviews were on waste management, as well as, waste minimisation in construction; as discussed in the following two chapters. Readers will benefit by learning about some of the refurbishment projects carried out in the city centre, the historical value of certain buildings and the relation that exists between waste management and total cost of the project. Hence, the analysis and findings will contribute to effective waste management and waste minimisation for refurbishment projects.

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1.3 Problem Statement

Several professional researches had pointed out the advantages in construction and demolition waste reduction. For example, Begum et al. (2006) stated that waste management in the construction industry is visually perceived as a low concern when there are existing cost constraints. Thus, the awareness of waste material on site will be neglected. It is recommended that the options for the perfect waste management procedure should be tenacious, considering cost implicative insinuations and cost relevance, which will result in waste minimisation. Moreover, Yahya & Boussabaine (2006) emphasised that waste generation by construction activities carry high particle contamination, which is very difficult to be recycled. As a result, the materials cannot be recycled and used again. This is where an increase in cost will take place. At the end of the day, the wastes generated will go to landfills. These costs will either impact the clients or the contractors. Sauders et al. (2004) suggested to liaise with major parties in every aspect of waste management due to the cost impacts, either to the clients or to the contractors.

Although there are numerous researches and journals that demonstrate the benefits of managing waste, there is still not enough information to increase awareness in waste management. One of the reasons that the researcher had conducted this study was to increase awareness of the public by implementing waste management into refurbishment projects.

As Maycox (2003) had noted, there is an obvious obstacle for waste management; insufficient education among the general public. Kulatunga et al. (2006) further suggested that for effective waste management, collective cooperation must be from all parties involved. On the contractors' side, the advantage of waste minimisation is reducing the

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total cost of the project. Therefore, this study investigated the factors that contribute to waste in refurbishment projects, and examined how they affect the total cost of the project.

1.4 Objectives

The objectives in this research are as follows:

1. To understand managing waste in the construction industry.
2. To identify factors that contribute to waste generation in refurbishment projects.
3. To examine the relationship between waste generation and cost performance.

1.5 Scope of Study

The focus of this thesis was to analyse the findings of variables that contribute to waste and its minimisation in refurbishment projects with the cost of projects. Kulatungam et al. (2006) stated that the most immense, colossal use of material quantity in the construction sector is in the span of 50-60% of the overall cost. In integration, huge varieties of materials are utilised in the construction sector. This percentage of material portion is not used effectively during construction. Furthermore, analysis had found that as much as 9% of overall construction materials end up as debris (by weight).

This study focused on refurbishment projects carried out in Malaysia. Refurbishment projects with unlimited tendering capacity were examined; this included contractor Grade G7 by CIDB, starting from year 2012 and completed by the end of 2014. The contractors were the respondents in this thesis report. The selected respondents are familiar with waste variables in the selected projects. 191 respondents had participated in this research; all respondents met the above requirements. The study concentrated on the major causes of material waste, which involved attitudes toward waste minimisation among labourers and contractors, material selection in tenders, design changes during construction, waste management and reuse of materials, reuse of facilities for recycling or sorting different types of waste, etc. As a result, it is important to raise awareness of waste minimisation in order to improve construction cost and fully utilise the materials during construction.

1.6 Methodology

Generally, the project methodology can be divided into 4 phases: literature reviews, data collection, data analysis and conclusion. In the literature reviews, the author studied the subject areas using related text books, journals and articles. In the data collection process, quantitative method was carried out by adopting questionnaire surveys. The questionnaires were distributed to respondents, who were mainly contractors that had various projects. Approximately 191 respondents had participated in this survey. In the analysis stage, the author used SPSS to check the relationship between waste variable with project performance, which is the total cost of the project. In the conclusion section, suggestions and recommendations were provided based on the findings.

Objectives	Method
Identifying the Problem Statement & Objectives	Literature Reviews
Data collection	Questionnaire Surveys & Interview Surveys
Data analysis	Descriptive Statistic (SPSS)
Conclusion	Related to Objectives

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1.7 Summary

In short, this research focused on acquiring the necessary data to identify the factors that contribute to waste generation in refurbishment projects, as well as, presenting the relationship between waste generation and cost performance.

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CHAPTER 2

MANAGING WASTE IN THE CONSTRUCTION INDUSTRY

2.1 Introduction

The objective to reduce waste is to minimise waste generation on site. Waste management is interpreted as generation, prevention, characterisation, monitoring, treatment, handling, reuse and residual disposal of solid wastes; whereas, waste minimisation is a process of elimination that includes reduction in waste generation and minimisation of harmful and persistent waste produced, assisting in the attempts to provide a better sustainable civilisation. According to Formoso et al. (1999), waste is interpreted as *"any losses produced by activities that generate direct or indirect costs but do not add any value to the product."* Koskela (1992) stated that construction waste is in *"relation to time delays, quality costs, lack of safety, rework, unnecessary transportation trips, long distance, improper choice of management, methods or equipment and poor constructability."* Generation of waste from property development, renovation, building demolition, etc., is known as construction and demolition (C&D) waste (Kofoworla & Gheewala, 2009). There is still room to improve construction waste management since the waste generated during construction is not fully managed; more awareness is required to achieve a perfect standard of management. Construction waste is a major environmental issue in most developed cities around the world (Chen, 2002). In reference to available statistical data, construction and demolition (C&D) waste are most often disposed in landfills in the past, making up around 10 to 30% of landfill sites (Fishbein, 2008).

Wastage of materials in any construction industry always affect the total cost of the project, and is parallel in providing the overall dilemma of national waste. Waste does not only increase the cost of a project, it has also become a serious issue to the environment. Hassan et al. (1998) reported that the average derivation of waste produced in the Central and Southern regions of Malaysia are 36.73% from household waste and 28.34% from industrial and construction waste, while the remaining 34.93% are from other sources such as markets, commercial waste, institutional waste, landscaping waste and street sweeping waste.

This shows that in Malaysia, construction forms a consequential portion of waste which is determinately disposed of in landfills. From that, it can be assumed that waste is a burden of extra cost, and does not add any value to the construction industry. Several studies were conducted to prove that waste is a burden on the construction industry with the following statements. According to Yahya & Boussabaine (2006), "wastage of materials in construction" refers to unused materials or those incapable of being used for their original purpose during construction, ending up as debris. Due to the large amounts of raw materials required in the construction sector, there is certainly a need to enumerate and evaluate the environmental impacts of waste produced from site activities. Subsequently, wastage of material is thereafter derived as the shortfall between the materials purchased and the actual quantity used in a project. According to Clark Country Solid Waste Management Plan 2000, construction waste is defined as "material that is produce as a direct result of building construction processes, such waste includes but is not circumscribed to cement, crusher run, plywood, plaster boards, sand, metal sheets, glasses, aluminium, tiles, paints, wire mesh, electrical wires, poly pipes and other kind of construction materials."

In reference to the above, it can be concluded that waste in construction is a side-effect and a consequence generated from construction, refurbishment and demolition activities owing to the high consumption of raw materials; this comprises of any material in solid, liquid or gaseous state that is no longer capable of performing its intended function.

2.2 Project Management

Project management is the discipline of carefully projecting or planning, organising, motivating and controlling resources to achieve specific goals and meet specific success criteria. In project management, functional actions are divided into operation areas by different professions in the construction industry. There are architects, engineers, contractors and others that require work independently. Every profession decides without taking into consideration the impact on others (Love, 1999). These professions carry out tasks that always follow their own agenda, target and value system. This results in each profession focusing only on their own tasks, with little understanding of the whole picture of the project that they had participated in. The actual situation is that the relationship between professions have become a possible obstruction to efficacious and productive communication and cooperation in the construction industry (Lahdenpera, 1995).

Management decisions and visions are always delayed and unclear when delegated to designated groups. Thus, nonfulfillment of quality will occur due to unproductive judgement (Josephson & Hammarlund, 1999). On top of that, without a present system, many involved parties are not aware of their own objectives. As a result, information accumulating, reporting and management in a project have become disorganised, with multiple redesigning of information being undertaken. Finally, this will lead to time consumption, dispensable costs, incremented errors and misconceptions, all resulting in a redo, which has been identified as the main cause of time and budget bursts in the construction industry (Love, 2002).

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The establishment of a variety of "fast-tracking" project procurement modules are undertaken by the project team to deliver better offers to clients and customers, who rapidly request for "well worth value" from their projects in terms of cost, time and quality. The various project procurement modules express several methods, processes and procedures for designing and constructing projects for clients. These modules also recommend numerous organisational structures of project teams in terms of role, liability and authority.

Project management is frequently related to construction projects, which basically consist of the most complex set of components that must be completed and assembled in a set fashion in order to create a satisfactory product. Project managers use visual representations of workflow, such as project management programs and Gantt charts to identify the critical path in the program, as well as, to decide which jobs are to be carried out by which parties.

2.3 Waste Management

Waste management strategies are suggested to reduce waste at the addressed source. In an article in 2001, Poon et al. stated that "*one of the most effective means of waste management is on-site sorting of construction and demolition waste*". The types of waste were divided into inert and non-inert, in which inert wastes consist of sand, crusher run, bricks and concrete; while non-inert wastes consist of bamboo, plastic, glass, wood, paper, vegetation and other organic materials which will eventually benefit the environment due to being faster in biodegradation (Jian et al., 2008). Sustainable waste management encourage waste material reduction, reuse and recycle. Jian et al. (2008) had argued that the recycling and reusing idea does not wholly comply with the sector due to higher management and overhead cost, insufficient professional expertise and lack of law enforcement legislation in the implementation of construction waste management. According to Seow & Mohamad (2007), even Waste and Public Cleasing Management Act 2007 (Act 672) is to regulate the management of controlled solid waste, but this act more focuses on avoiding the waste from contributing to improper sanitation. Although it covers on construction solid waste as part of controlled solid waste, but it still not detail enough for the industry.

According to Begum et al. (2006), the existing process of construction debris flow by the category of generation, waste, transitional and dumping, as well as, the quantum of waste minimised, reused or recycled are all data not readily found in the Malaysian construction industry.

As a result, this research relied on overseas waste management research. There is a wide range of methods for disposing waste from construction and demolition processes, which range from reducing and recycling to incineration and landfilling. In advance, considering the different ways that could be adopted, a hierarchy of disposal options was established in the following figure. This is to mainly accentuate the minimisation of resource consumption and environmental damage.

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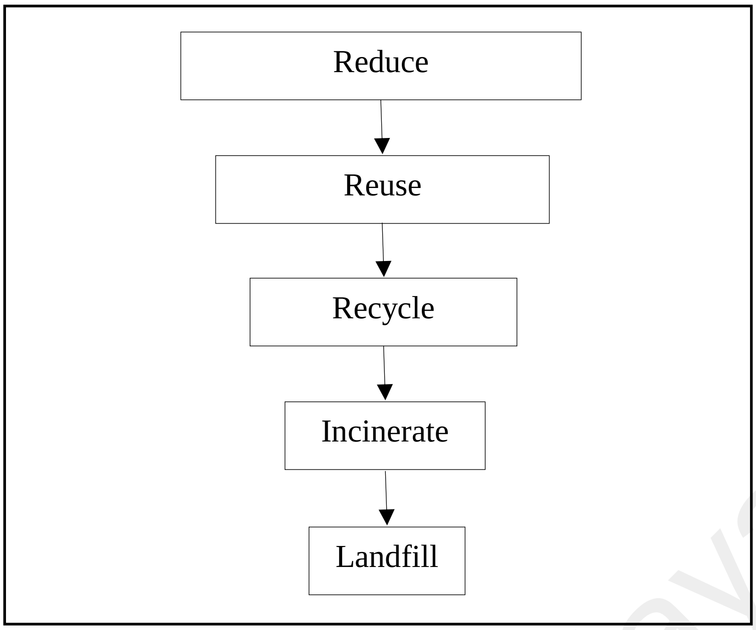

Figure 2.1: Hierarchy of C&D waste material handling

Source: Chun, Scorpio & Kibert (1997)

2.3.1 Source Reduction

Source reduction, or waste minimisation, covers the design, manufacturing, procurement or usage of construction materials in a process of reducing the quantity of toxicity prior entering the waste management system (Pichtel, 2005). Unfortunately, preventing the generation of waste, over-storage, gathering, getting rid of waste burden and responsibilities are being neglected. Waste prevention is the effective way for reducing the generation of waste; eliminating many waste disposal issues. Generally, major industries pick out dangerous materials due to the rising cost of handling toxic wastes; the effort to reduce it is stimulated as well. In light of that, the increasing cost will drive a concrete reason and factor to eliminate dangerous waste.

In an article in 2004, Cheung et al. claimed that the use of precast elements such as precast façade, prefabricated bathrooms, precast cladding, etc., could considerably lower the amount of waste generated which will then avoid the application of cast in-situ works that tend to contribute the greatest portion of waste during the entire project. The ultimate

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option to reduce waste in landfills is to fully utilise waste reduction practices during the design phase, as well as, the construction stage. This can be implemented by on-site sorting of construction wastes before disposal, which will eventually lead to recycling (Cheung et al., 2004).

2.3.2 Recycling

According to Begum et al. (2006), recycling is defined as the recovery or reuse of whatever leftover material that would otherwise end up as waste. It is crucial that all parties are involved in implementing recycling and consider turning materials into scraps, especially in this generation of the "Go Green" concept, where material value has become the top priority in the construction industry. In other words, recycling in the construction context simply means reprocessing construction waste into new products that can be employed in building activities. As shown in Figure 2.1, the rank of 'recycle' is a considerably high priority in the hierarchy of construction waste disposal. Recycling does not only make new materials out of wastes, but also generates economic benefits in another perspective.

The increasing cost of disposing waste has resulted in a tremendous increase in the construction industry's interest in recycling (Piehtel, 2005). In an article in 1997, Kibert proposed a better value-added recycling manner for construction and demolition wastes instead of incineration and landfilling. Thus, recycling will become a very important process of managing construction waste on site due to its environmentally friendly characteristic; efficiently reducing the amount of waste directed to landfills. Recycling construction waste will minimise the amount of disposal, hence, the life span of landfills can thereby be extended.

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2.3.3 Incineration

Incineration is a modern technology that reduces the mass of waste by up to 96%. Pichtel (2005) defined incineration as a process of "controlled burning of solid, liquid or gaseous wastes". He further elaborated that "controlled" can be in a condition where an oxygen-enriched combustion chamber is under several stages of temperatures, using highly burning fuel and the ignition of debris. The final products from incineration are individual based model (IBM), gasses and heat; and these will be used for generating electric power. In the past, incineration was done without separating the hazardous material from other materials, and was mostly accomplished without energy recovery. This resulted in combustion gasses, which are a risk to the environment and mankind.

According to Kibert (1997), the construction industry is beginning to consider burning the wastes generated during construction activities as the landfill space is rapidly decreasing. However, he also claimed that the environmental effects caused by the municipal waste incinerators are the reasons that stopped the industry from executing this management approach. Incineration could result in the threat to health and nature since the process involves acid gas emissions, such as hydrogen chloride, sulphur dioxide, as well as, hazardous metals like lead and dioxin. It relates back to the very first mega incinerator in Semenyih in year 2003, it has forced to shut down due to above and various reasons. One of it is Malaysian did not practice segregation of waste.

2.3.4 Landfill

From Figure 2.1, landfill is located at the lowest position in the hierarchy, and it should only be considered when all other alternatives of managing wastes are exhausted. According to Department of National Solid Waste Management, The Ingenieur (2009), There are 289 sites in Malaysia as for landfill, however, 113 out of 289 are no longer in operation due to environmental issue or reached the full capacity. Most landfills are from inert waste. Inert waste consists of sand, crusher run, bricks and concrete which are mostly from the construction sector. However, there are material categories such as non-inert waste in construction. These include timber, bamboo and organic construction materials not suitable for landfills. Kibert (1997) suggested that poisonous gas emission and water contamination are common problems that occur due to mixed construction wastes in landfills. In terms of sustainability, landfilling should not be considered as a manner of managing waste in construction sites as it will jeopardise the environment, as well as, allocate a risk on the consumption of materials used in construction (Chandrakanthi, Hettiaratchi, Prado & Ruwanpura, 2002).

2.4 Factors Influencing Waste Management on Site

Advantages of proper practices for material management on project sites would be conservation of materials and reduced construction waste. There are significant amounts of materials that end up as waste due to improper waste control on project sites. There is a necessity for recognising the roots of low awareness in construction waste management to achieve better project performance in terms of economics, standards and sustainability of products.

Haigh et al. (2006) had argued that perspective and perception of the construction manpower is the main barrier to achieve effective waste management practices in the industry. He further elaborated that the negative thinking of ground people when judging the wastage of materials is an unavoidable by-product. The belief that other environmentally friendly alternatives will not be able to reduce the amount of waste generated is the reason behind poor waste management in construction sites. The industry is labour-intensive by nature.

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Having a deficiency in paying attention to the management of construction wastes during the pre-construction period is another factor influencing waste management on sites (Haigh et al., 2006). Difficulties in changing existing work practices have led contractors to concentrate on other tender strategies rather than focusing on construction waste handling allowances. Conversely, it is only initiated in post-contract processes where after the construction activities have already begun, waste management will only then kick in.

Apart from that, Haigh et al. (2006) further claimed that time constraint is another contributor towards lack of waste management practices in construction sites. Within the contract period agreed upon in the contract, the contractor may find that there is an insufficient time frame to implement a waste management plan in the actual context on local construction sites. For instance, in the sense of recycling or reusing spoiled bricks, contractors would rather use proper bricks because it would be easier and time saving.
Financial incentives come into consideration for the effective implementation of construction waste management in local construction sites (Wong & Yip, 2004). When the construction waste management of local construction activities is organised in such a way that it rewards fast workers who are able complete their work in a certain time frame by being paid on a rate basis, labourers will tend to use new resources compared to modifying old or used ones.

Other than that, Wong & Yip (2004) also proposed that it is the philosophy of the construction sector itself that influences effective and sustainable waste management practices on local construction sites. Generally, there is an insufficient industry norm in the local construction sector context in which there is proper and standard policies on implementing waste management, resulting in poor waste management in many construction companies.

There is certainly a necessity in the requirement of more personnel and workforces on construction sites for effective execution of waste management practices (Haigh et al., 2006). This implies that the cost factor is considered when dealing with recruitment of more human resources in executing waste management on local construction sites.

2.5 Current Prevention of Waste Generation

Waste generated in the construction sector has become part of the largest solid waste in Malaysia. Tremendous amounts of construction and demolition debris are resulting from current construction activities, refurbishments and demolition processes. Therefore, it is important to have long-term solutions for the construction sector in using recycled materials, or "green" products, in order to provide a healthy and sustainable environment.

It is very unfavourable when it comes to looking for new dumping areas, particularly in the situation where there are competitive requests for limited dumping areas in our local construction industry. Hence, other effective means for handling waste in construction sites would be worthwhile in reducing the disposal of waste at landfills.

Contractors are trying hard to look for other alternatives to eliminate waste and increase profit due to the tight profit margins and high competitive tender prices in construction projects (O. Salem, J. Solomon, A. Genaidy & M. Luegring, 2005). It was further indicated that implementing lean construction to measure the sector will bring about the reduction of construction waste on site and increase profitability and productivity. The idea of lean construction is shown in the following figure:

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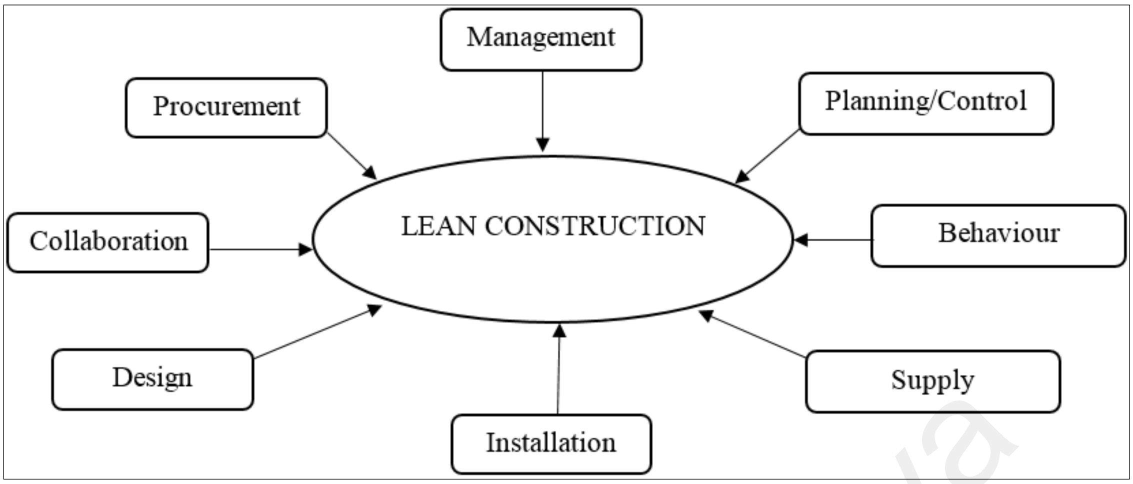

Figure 2.2: System of lean construction

Source: Eric Johansen & Lorenz Walter (2007)

In general, lean construction is the same as current exercises in the construction sector where both practices aim for better fulfilment of customer needs while reducing waste for every resource in every possible stage. It is very crucial for all parties involved in construction activities to be equipped with proper education in waste management for the entire construction process by organising daily meetings for a two-way communication in waste management (M. Luegring et al., 2005).

The application of lean construction in the local construction industry context will improve safety, productivity, quality, create more spaces, reduce idle time, improve morale and teamwork and, most importantly, eliminate waste resources that meet the aim of waste management in construction sites. Thus, the implementation of the 5s process should be emphasised during all meetings to achieve the aim mentioned above, while simultaneously maintaining a two-way communication.

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2.6 Cost in Waste Implementation

The cost for waste implementation is always taken in comparison to the advantages for an organisation (Shen & Tam, 2002). Waste grouping, as well as, segregating values for reuse and recycle relies on the following conditions: the occurrence of grouping and segregating waste on the project site, the daily duration required in grouping and segregating, the number of workmen required in grouping and segregating in a day, their daily wages and the total value of the daily waste grouped and segregated. The total immediate value of reuse and recycle are defined as the value of grouping and segregating construction waste material, apparatus buying cost, storage cost and shipment cost. This proves that no indirect cost is related with the reuse and recycling of waste materials at construction sites.

Common feasibility study is conducted by the analyses and findings in profitability such as cost budget analyses. Most analyses had found that there are numerous advantages in implementing waste minimisation. These include advantages to the environment, financial benefits, community perspectives and others (Esin & Cosgun, 2007; Lorton et al., 1988). If waste minimisation is managed properly, it provides better finances for businesses, enhancing productivity, profits, corporate social responsibility, quality and a better environment. Below are further findings on the benefit-cost analysis, along with finance of waste minimisation in construction.

Financial analysis plays a crucial role in the implementation of waste management system for the construction sector. Every aspect of cost must be considered when conducting financial analysis for waste minimisation, such as the reuse and recycling of debris in construction. The financial analysis results could identify the direct, indirect and intangible merit points of reusing and recycling debris, as well as, the total revenue generated in reuse and recycling activities. The financial analysis is accompanied by a conventional way of evaluation, as it is the origin of the research, where the financial aspect is referring to the opportunity of the cost approach.

Cost is the main factor for selections and options in the waste management process. Waste management in the construction industry is visually perceived as a low concern when there are existing cost constraints. It was recommended by Coffey (1999) that effective minimisation of waste material could result if waste management was applied during construction projects.

He also added that the choices of effective waste minimisation alternatives should be determined by considering the cost implication, methods of reducing waste, etc. In actuality, higher management in construction parties usually focus on the overall construction time and cost; whereas, waste minimisation is always given the least amount of commitment and is generally neglected.

2.7 Summary

With proper assistance to client projects, parties with better experience in techniques and procedures of construction should be awarded, where they can assist in decision-making processes during pre-tender stage to avoid unnecessary works throughout construction. This will result in less time consumption and waste. This will further benefit in the reduction of frequent design changes, which is also attributed to wastage. Contractors must be fully equipped with knowledge from their experiences regarding cost saving to manage reduction or to eliminate construction waste. Advantages in waste minimisation activities need to be highlighted to clients. Results from the above-mentioned actions will attribute to a reduction of waste materials in Malaysia's construction sector. From this

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chapter, it can be concluded that the material waste occurs in the following stages: design, procurement, material handling and operation stage. Therefore, the researcher concluded that when conducting the survey for this study, the survey should be distributed to individuals involved in design, procurement, material handling and operation in the construction industry; in other words, the quantity surveyor, project engineer, project manager and project director. Moreover, the conducted survey must be evenly distributed throughout these stages so as to ensure the accuracy and reliability of this research.

CHAPTER 3

CONSTRUCTION WASTE GENERATION FACTORS

3.1 Introduction

The market trend and demand in this decade is about sustainable buildings and environmentally friendly developments where it can greatly enhance the financial, environmental and social responsibility of existing properties. Researches show that up to 90% of construction activities are completely done by a group of subcontractors, while the main contractor is designated to focus on management and coordination (Khalid, Marton, & Steven, 2006). On-site works are usually divided into small contracts due to the professional scope of work and different types of construction trends. Normally, the main contractor will overlook waste management and may leave it to the subcontractors. The implementations of waste minimisation are difficult and hard to control due to limited material storage. During the planning and design stages, lack of consideration in reducing the generation of waste had caused excess construction materials to be wasted. Reducing waste of materials in construction is the most competent way for minimising generated waste and avoiding excessive debris handling issues (Peng & Scorpio, 1997). On top of that, Egan (1998) emphasised that to improve the quality and efficiency of the construction sector (including refurbishment projects), waste reduction during every stage in the construction process should be implemented.

The previous chapter had discussed waste management. In this chapter, the researcher investigated the project performance of the construction industry and refurbishment projects. Moreover, the factors that contribute to the generation of waste were examined. In construction or refurbishment projects, performance is used as a measure to evaluate the inputs, outputs and final outcomes of the project. The research by Freeman & Beale

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(1992) contributed to the measurement of project success from the tangible and non-tangible features; where the tangible ones are in terms of cost and time, and the non-tangible consist of customer satisfaction, the performance of the project manager and other attributes. Performance is defined as "*the degree of achievement of certain effort or undertaking*". It is used to promote targets and aims which become the project's milestones (Chitkara, 2005). In the project management's point-of-view, the target is more about meeting stakeholders' expectations and needs for construction. It also consistently covers three major project elements: i.e., time, cost and quality. Nowadays, strong competitiveness and an unstable business nature have driven major stakeholders to expect shorter time for project delivery. In such a short period of time, they expect the project to meet the quality at lower cost so that their money is worth the investment. However, such a short time frame could also lead to higher risks of errors, wrong design, as well as, inaccuracy in the estimation of cost. Despite the majority of parties involved being relatively focused on the elements of cost, quality and time, waste management also plays an important role in project performance.

In this research, the key performance related to waste management is the total saving of cost from waste management during the project. The objective of this research was to identify the most important sources of construction waste in Malaysia, and to minimise them. Design, operation, procurement and material handling are all related in this context, and these were consequently evaluated by data analysis. The purpose of waste minimisation in this research is to reduce the total cost of the project, and ensure better sustainable development in Malaysia.

The researcher investigated the factors of waste generation in refurbishment projects in order to gain a clearer picture on how waste is generated as unused materials.

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Furthermore, the factors that contribute to waste generation were examined. Regarding waste generation, the researcher focused on the minimisation of waste generation in refurbishment projects due to the rapidly increasing importance of the refurbishment industry, and the requirement for better information and expertise in managing them.

3.2 Review of Construction Waste in Malaysia

Under the Environmental Quality Act 1974 (Act 127), waste is classified as any matter specified as routine debris in any form such as solid, highly viscous liquid, gas or vapour which is either discharged or dumped on earth in any quantity, composition or situation resulting in pollution. Construction debris is defined as debris in either the solid, liquid, or gas states (or a combination of any of these conditions). Due to mass utilisation of raw materials in the construction industry, there is certainly a need to enumerate and evaluate the damages caused by construction debris.

According to Kwan et al. (2003), it was indicated that although there is a well-known worldwide urgency in developing sustainability, the construction sector is still famous in generating high quantities of construction and demolition debris. Subsequently, construction debris is, thereafter, derived as the variant between materials ordered and the actual materials used during construction.

Construction and demolition waste are often combined as the waste sub stream, consisting of similar materials that are generated from two different but related activities during the development of projects. Construction and demolition wastes are produced from new building constructions, renovations or demolition activities.

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From the above reference, construction waste is a side-effect or consequence generated from construction, refurbishment and demolition activities owing to the high consumption of raw materials which are comprised of any material in the solid, liquid or gaseous state that is no longer capable of performing its intended function.

In Malaysia's construction industry, data is not readily available on the existing processes of construction debris flow in the category of generation, category of waste, transitional and dumping, or the quantum of waste minimised, reused or recycled. A study by Sivapalan K. et al. (2002) stated that the generated waste is increasing annually in Kuala Lumpur. Proper waste management should be implemented in order to reduce such waste. The following table indicated the amount of waste that was generated and forecasted in Kuala Lumpur.

Table 3.1: Municipal solid waste generated in Kuala Lumpur

Year	Population in Kuala Lumpur	MSW Generated (tonnes/day)	Source
1970	-	98.8	1
1980	-	310.5	1
1990	-	586.8	1
1998	1,446,803	2,257	2
2000	1,787,000	3,070	3
2005	2,150,000	3,478	3

(Source: Saeed M.O et al., 2009)

From Table 3.1, it can be noted that the municipal solid waste (MSW) generated per day is increasing annually. If this continues to rise, more landfill space will be filled up by MSW. To overcome this problem, the best way is to reduce the rate of waste generated during construction and refurbishment activities in Malaysia. Therefore, it is necessary to

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establish the main factors that contribute to material waste in the construction process. This chapter employed an analytical review to assess the wide range of factors in the wastage of materials, from the beginning of the project to its completion. Data acquired from this chapter will assist researchers and construction players in providing sustainable and cost-efficient projects in future.

3.2.1 Waste Generation in Refurbishment Projects

As discussed in the first chapter, refurbishment has become the popular solution when considering developments. People now prefer refurbishment where in the UK, the number of refurbishment projects had multiplied tremendously in the past 30 years. This is now influencing Malaysia which saw a refurbishment increase of 16% from the total construction output in the year 2006, compared to only 2% in the year 2002. It is an upward trend within the last decade where people are shifting to building reuse and adaptation processes (Kholer, 2006; Van Beuren & de Jong, 2007). The past decade had witnessed increasing needs for refurbishment projects. Many existing properties are aging, and owners and tenants are desperately searching alternative ways for energy efficient and environmentally friendly solutions. Refurbishment projects have less impact on the environment compared to demolition and reconstruction projects (BFM. & BRE., 2004). This is because the total usage of new materials is significantly lower than new construction. The materials and components that are dismantled from refurbished building contents have higher potential for recycle and reuse. With appropriate planning and design, management in handling waste from refurbishment projects will encourage the implementation of waste minimisation on site.

Along with the growth of refurbishment projects in Malaysia, waste implementation and sustainability have become a barrier for development. One research had indicated that as

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much as 9% of the total materials delivered ended up as debris, and the range between 1 to 10% for each material contributed to solid waste from the site (Bossink & Brouwers, 1996). Buildings that undergo refurbishment processes are usually occupied by existing tenants, and this will lead to limited space and short time schedules for site work. Furthermore, most refurbishment projects are carried out in the city centre, where on-site waste has always been a critical issue for development. Methodology of waste handling, traffic management plan, environmental issues, public awareness and designated places for disposing waste are always interrelated.

According to Bullen & Love (2011), cost is the main reason for choosing refurbishment to redevelop a building. Unfortunately, waste generation in refurbishment is significantly and directly related to the project cost. The greater the wastage of materials in refurbishment projects, the greater the cost incurred to the total cost of the project. As a result, higher resources will end up becoming waste at the end of the day.

3.2.2 Categorisation of Wastes

Construction waste from project sites are normally the scraps of construction materials such as wood, bricks, rocks and aluminium. Waste streams significantly vary within several construction stages; the fraction and volume of wastes were shown in Figure 3.1.

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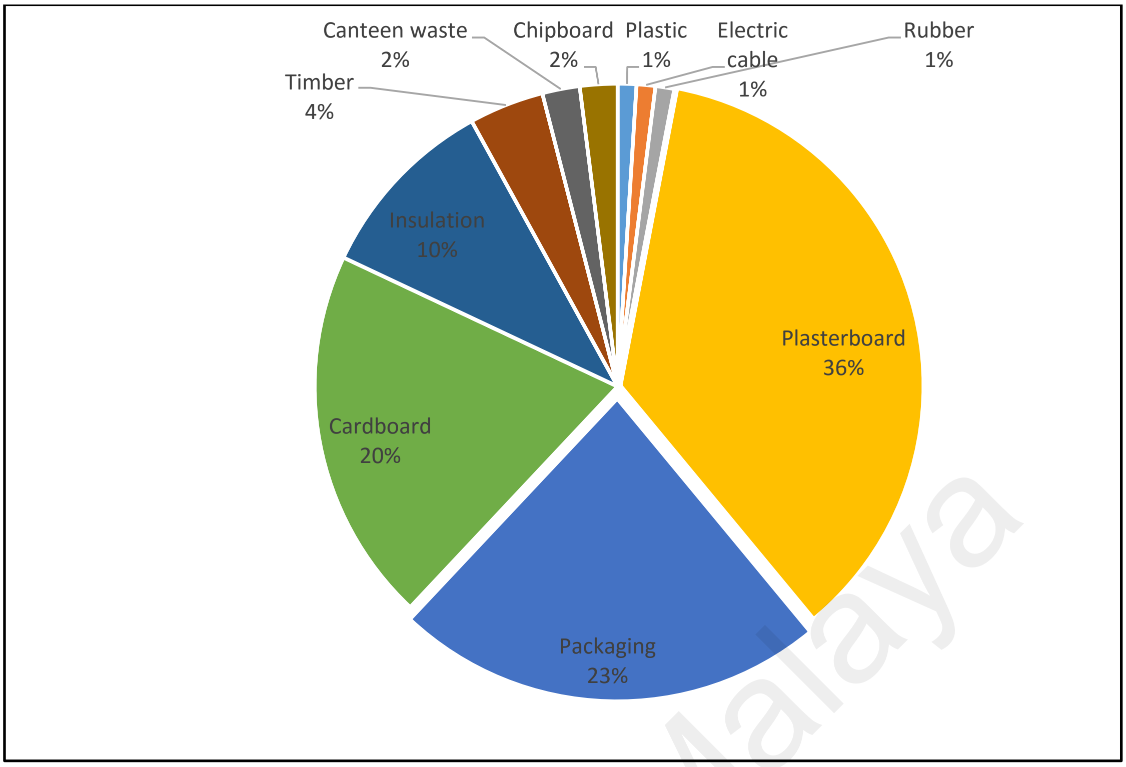

Figure 3.1: Waste fraction at various phases of construction

Source: Yahya & Boussabaine (2006)

Figure 3.1 presented the types of waste components generated at construction sites. From the above-mentioned references, construction debris is categorised by its components; i.e., wood, metal, drywall, plastic, roofing, rubble, glass, bricks, etc.

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Table 3.2: Typical components of construction and demolition wastes

Materials	**Examples**
Wood	Forming and framing lumber, stumps, plywood, laminates, scraps
Drywall	Sheetrock, gypsum and plaster
Metals	Pipes, rebar, flashing, steel, aluminium, copper, brass and stainless steel
Plastics	Vinyl siding, doors, windows, floor tile and pipes
Roofing	Asphalt and wood shingles, slate, tile and roofing
Rubble	Asphalt, concrete, cinder blocks, rock and soil
Brick	Bricks and decorative blocks
Glass	Windows, mirrors and lights
Miscellaneous	Carpeting, fixtures, insulation and ceramic tile

Source: Pichtel (2005)

3.3 Factors that Contribute to Generation of Waste in the Construction Industry

Wastage of materials takes place across the lifecycle of the construction process. This is due to poor construction planning, lack of knowledge in the project, as well as, external factors such as theft and vandalism. Negligence in the planning and design stages, such as lack of consideration in waste reduction, will usually result in extra construction materials.

There is a wide range of reasons in waste generation on site, as quoted by Gavilan & Bernold (1994); the wastage of materials can occur due to several causes. Craven et al. (1994) explained that the primary roots for the wastage of materials are mistakes in contract documents, alterations of the design, errors in ordering, accidents, lack of supervision, insufficient waste management input, etc. Construction parties are still hesitant in practicing low-waste programs as they are expensive to implement and possess insufficient design coordination which has a big influence on construction waste generation due to the uncertainty of controlling construction waste (Chen et al., 2002). The findings on the generation of waste are controlled by a variety of circumstances and are classified as:

I. design
II. handling
III. management
IV. site condition
V. procurement

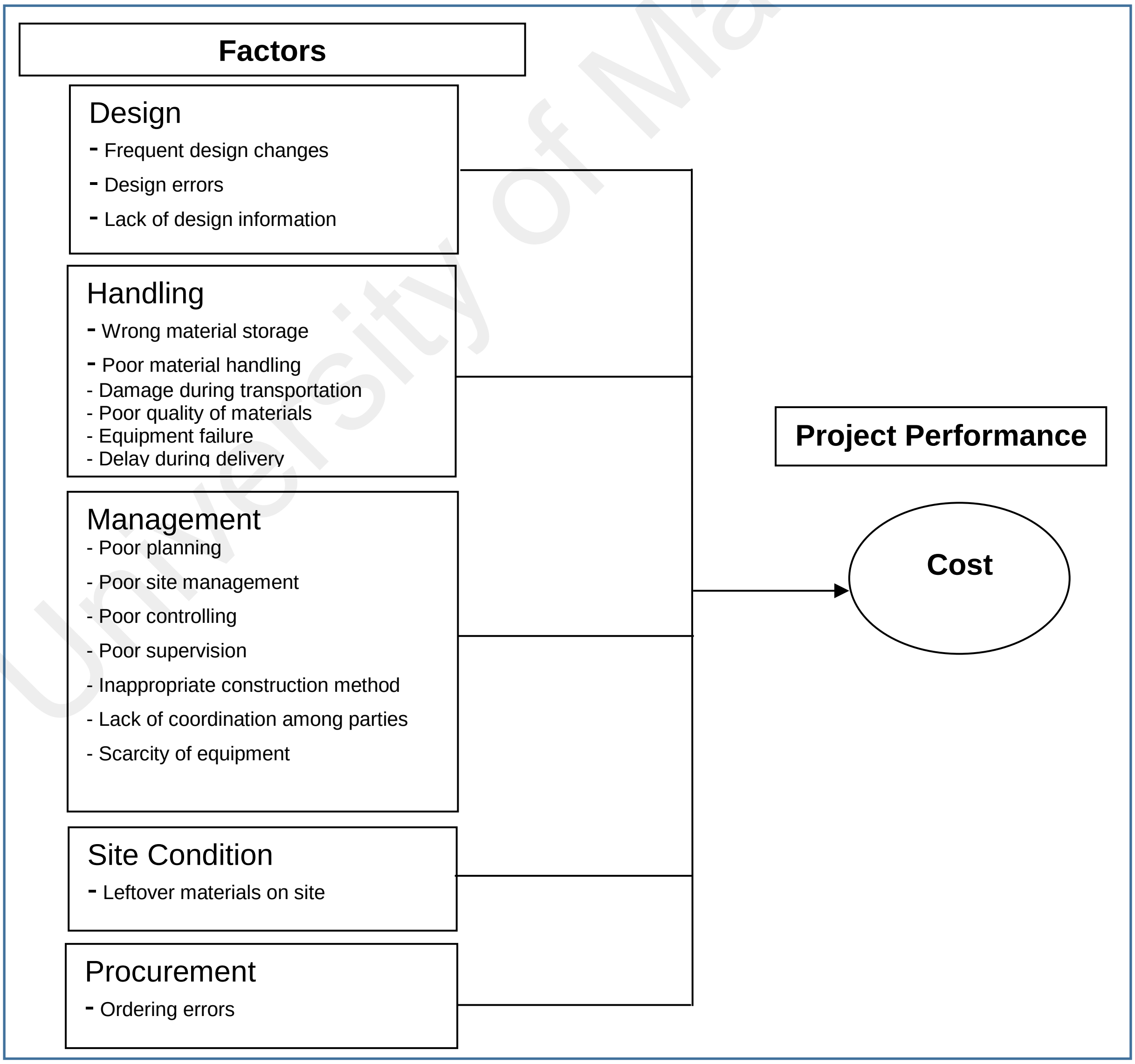

Figure 3.2 Theoretical framework of factors that contribute to the generation of waste

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3.3.1 Design

The causes of construction and refurbishment wastes under the design category are as follows:

a) frequent design changes
b) design errors
c) lack of design information

According to Ekanayake & Ofori (2000), waste generated is usually because of lack of attention paid on the dimensional coordination of a product. This is due to the miscommunication between the design team and the construction team, where there is unnecessary extra work to be done in the project, yet it contributes nothing to the project (Keys et al., 2000). This can be avoided by informing clients about the impact of waste generation and the benefits of saving cost. Otherwise, changes made to the design during construction will influence the generation of waste. An example would be a project that had completed the foundation of the building but must now be modified due to structural changes from the design team; this will increase cost, and rework must be done on the previous stage to construct the new foundation, causing huge quantities of waste in concrete and reinforcement bars (Yunpeng, 2011). In addition, there are several causes in the design stage that contribute to waste generation, such as: employing designers with inadequate experience in procedures and processes of construction; absence of attention to product market availability; inexperienced designers regarding other similar products; drawing complications; inadequate drawing information; mistakes in contract documents; delays in forming contract documents; and using cheap quality products, resulting in delays in construction and increased cost due to unnecessary reworks.

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3.3.2 Handling

Causes of construction and refurbishment waste under the handling category are as follow:

a) wrong material storage

b) poor material handling

c) damage during transportation

d) poor quality materials

e) equipment failure

f) delay during delivery

From the hypothesis, these are the causes of handling that are assumed as waste generation in construction projects. Material handling occurs throughout the construction stage, from the design stage until handing the project to the client. It covers damage and spillage, impurity of materials, exceeding the expiry date and wrong estimation of material supplies (Ekanayake & Ofori, 2004). Nagapan et al. (2003) explained that the existing problem is always related to improper storage methods due to handling activities. Materials that should be handled with care are neglected because of human error. Thus, material handling is one of the longest period factors that should be considered throughout the project, and is one of the major factor that contributes to the total cost in project performance.

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3.3.3 Management

Causes of construction and refurbishment waste under the management category are as follows:

a) poor planning
b) poor site management
c) poor control
d) poor supervision
e) inappropriate construction methods
f) lack of coordination among parties
g) scarcity of equipment

The management factor that contributes to waste generation is during the operation stage. In this stage, errors occur due to labourers during operations, accidents due to negligence, damage to work already done and the use of incorrect materials resulting in rework or replacement of a particular element. In the operation stage, delays in transferring information to the contractor on types and sizes of products to be used, as well as, equipment malfunctioning are also causes of time waste. In addition, worker mistakes are common causes in generating construction waste. Worker mistakes are due to insufficient training, lack of appropriate skills and poor working attitudes. In particular, contractors require workers to be on site on a project basis, and these workers are usually ignored when it comes to honing their skills (Ling & Nguyen, 2013). Among all the material waste generated from workers are bricks, light weight concrete, plaster and tiles. Selecting competent workers to match skills during site works could reduce worker mistakes. In addition, supervisors should monitor construction workers on site. The close supervision will ensure that workers are more alert and responsible in their tasks. Implementing periodic awareness programs for workers may also influence a better working

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environment and minimise mistakes throughout routine works. The above actions may reduce waste generation during the operation stage.

3.3.4 Site Condition

The cause of construction and refurbishment waste under the site condition category is as follows:

a) leftover materials on site

Leaving materials and never applying them for a long time would fall under the site condition factor, where such construction waste can be visually seen. This issue consists of additional steel bar cutting, unused formwork, unused broken bricks and other construction materials that can be seen near the completion of the project. Bad attitude and lack of management causes large amounts of site residues (Wang & Li, 2011). During the housekeeping process, the management or supervisors are responsible in ensuring that good materials are filtered and returned into the storeroom. Project managers can arrange and sell leftover waste materials to recycling organisations. This arrangement will eventually decrease the space needed for construction waste, and cost reduction will be a profit when selling recycled materials.

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3.3.5 Procurement

The cause of construction and refurbishment waste under the procurement category is as follows:

a) ordering errors

From the research, it was found that ordering errors generated unnecessary waste. Over supply and excessive materials in refurbishment projects all become waste. Bossink & Brouwers (1996) had explained that ordering errors in the procurement factor could affect the execution of the project since the total cost of the project will increase due to the re-ordering process. The increase of cost can be avoided with better procurement management and several appropriate implementations.

3.4 Matrix of Causative Factors

There are many previous researches that identified factors in the generation of waste, which provided an introductory picture in the plotting of factors (Jackson et al., 1990). Therefore, a matrix of causative factors was used to plot every identified factor appearance from global researches conducted by frequency, and presented in a table. 20 examined papers were obtained in this analysis, and 18 wastage of material factors were determined in this study. These identified variables were then categorised into 5 elements, as displayed in Table 3.3. The initial relevancy of every variable for this research can be found from the table, and this provided useful information when designing the questionnaire.

Table 3.3: Matrix of causative factors of waste generation

GROUP	CAUSE OF CONSTRUCTION WASTE	REFENCES																				F	Percentage
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)		
DESIGN	frequent design changes	1		1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	18	90%
	design errors	1		1		1	1		1		1		1				1		1	1	1	11	55%
	lack of design information				1	1	1	1	1	1						1						7	35%
HANDLING	wrong material storage	1		1	1			1	1	1	1	1		1	1		1	1	1	1		14	70%
	poor material handling	1		1	1	1		1	1	1		1		1			1	1	1	1		13	65%
	Damage during transportation				1			1			1	1		1	1		1				1	8	40%
	poor quality of materials								1	1	1			1	1	1	1		1			8	40%
	equipment failure			1	1						1		1		1				1			6	30%
	delay during delivery					1			1	1			1			1						5	35%
MANAGEMENT	poor planning	1	1		1	1			1	1	1		1			1	1			1		11	5%
	poor site management			1	1			1				1	1	1	1		1			1		9	45%
	poor controlling		1			1		1			1		1			1	1	1		1		9	45%
	poor supervision								1	1			1		1	1	1				1	7	35%
	inappropriate construction method					1			1	1		1				1	1		1			7	35%
	lack of coordination among parties					1		1	1	1							1			1	1	7	35%
	scarcity of equipment					1			1	1			1			1	1					6	30%
SITE CONDITION	leftover materials on site	1		1							1				1			1				5	35%
PROCUREMENT	ordering errors	1		1	1	1		1			1			1	1		1	1	1			11	55%

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3.5 Waste Minimisation for Construction & Refurbishment Waste

Waste minimisation for construction and refurbishment waste is crucial in developing a successful and sustainable market; unfortunately, there is yet additional waste generation, incorrect ways in waste management and the lack of awareness on the importance of waste reduction. Coffey (1999) had proposed several waste management strategies. He stated that it is difficult to prioritise waste minimisation, especially when running out of total construction budget. He also added that with well-planned finances, any implementation for a project within budget could be achieved, benefitting the overall project. Here, waste implementation by the waste management plan was studied, and the efficiency of several types of waste implementations were discussed.

The obvious benefits of waste minimisation in construction projects would be cost and time savings. Several analyses had proven that the driving force for waste minimisation on site entailed the encouragement and education of workmen to be involved in waste management, thereby, treating waste management as part of their safety precautions (Lingard et al., 2001). A well-regulated, tidy, path with an observed construction site in which material inputs and outputs are always monitored will lead to lower occurrences of fatalities and accidents due to unpredictable incidents. Moreover, a healthy discipline regarding waste management inspires involved parties to look for efficiencies, cost reduction, as well as, reduce the wastage of materials. Desperation for diminishing the environmental impact from construction waste has encouraged the whole system of waste minimisation (Cheung et al., 2004). This phenomenon is being noticed by some developed countries, and is expected to grow more in future (Lockwood, 2006). Techniques on factors of waste minimisation are

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known as variables in this research. Variables were then further investigated in their relation between project performances and the cost of the project.

From Figure 3.3, Begum et al. (2006) mentioned that waste minimisation covers source reduction and recycling. Source reduction is summarised as: *any activity that reduces or eliminates the generation of waste at the source, usually within a process*.

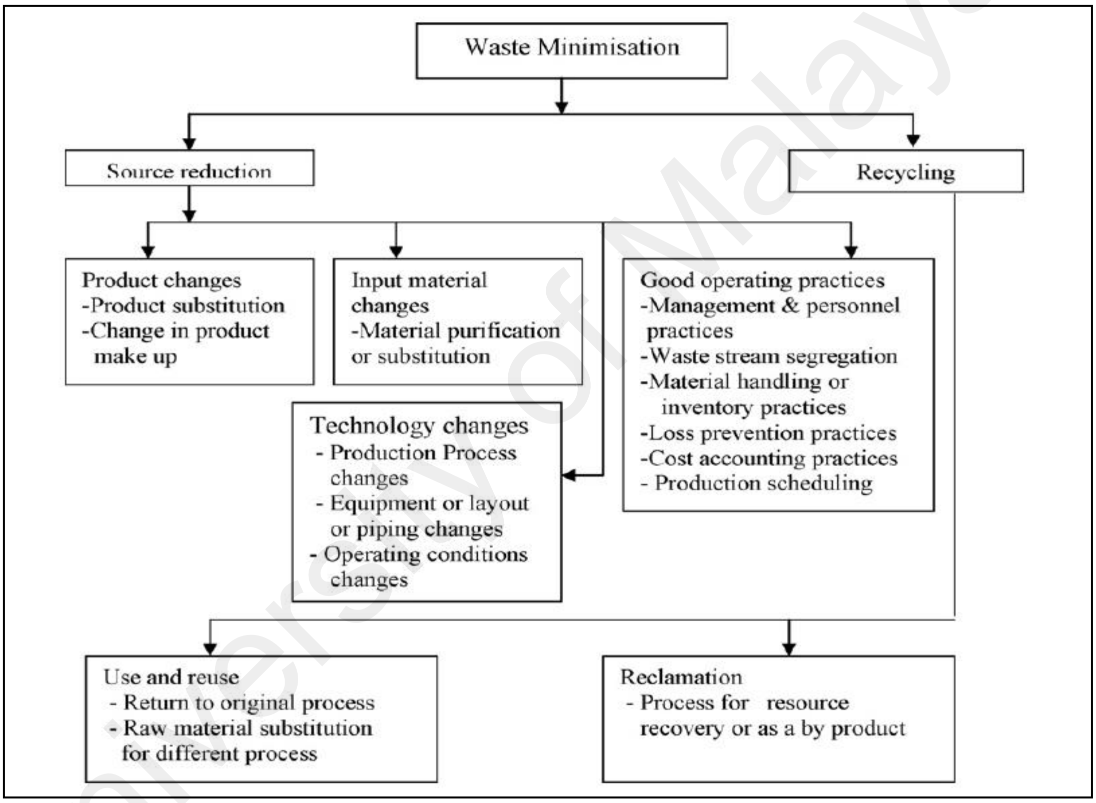

Figure 3.3: Waste Minimisation Practice Diagram

(Source: Begum et al., 2006)

Whereas, recycling covers the retrieval or reuse of unwanted materials. As a result, source reduction and recycling were part of the implementations for waste minimisation. From a previous study, Tam (2007) had finalised effective measures in

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implementing waste management variables, and they are the closest to the objectives of this research. As a result, the researcher took the following variables for this study.

I. *Use of prefabricated building components*
II. *Purchase management*
III. *Education and training*
IV. *Proper site layout planning*
V. *On-site waste recycling operation*
VI. *Implementation of environment management systems*
VII. *High level management commitment*
VIII. *Install underground mechanical wheel washing machines*
IX. *Identification of available recycling facilities*
X. *On-site sorting of construction and demolition materials*
XI. *Use of metal formwork*
XII. *Central areas for cutting and storage*
XIII. *On-site waste conservation*
XIV. *Use of information technology on-site*
XV. *Use of non-timber hoarding*

According to a survey conducted by Tam (2007), the relative importance index was related with effective measures in carrying out waste management plan solutions. The results were presented in Table 3.4.

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Table 3.4: Relative importance index for effective implementation

Relative importance index for effective measures in implementing a WMP method			
Effective measures in implementing a WMP Method	$\sum w$	Relative importance index	Ranking
Use of prefabricated building components	306	0.805	1
Purchase management	294	0.774	2
Education and training	294	0.774	2
Proper site layout planning	290	0.763	4
On-site waste recycling operation	288	0.758	5
Implementation of environmental management systems	280	0.737	6
High level management commitment	278	0.732	7
Install underground mechanical wheel washing machines	256	0.674	8
Identification of available recycling facilitate	254	0.668	9
On-site sorting of construction and demolition materials	252	0.663	10
Use of metal formwork	244	0.642	11
Central areas for cutting and storage	238	0.626	12
On-site waste conservation	228	0.600	13
Use of information technology on-site	224	0.589	14
Use of non-timber hoarding	222	0.584	15

(Source: Tam, 2007)

According to Tam (2007), 15 variables were suggested within the waste implementation method in Table 3.4. From the results of the relative importance index, "Use of prefabricated building components" was considered as the most effective solution in waste minimisation. Next, came "Purchased management" and "Education and training" as the second and third places. "Proper site layout planning" was in fourth place, followed by "On-site waste recycling operation" in fifth place. As shown in Table 3.4, "Implementation of environmental management system" (in sixth place) and "Install underground mechanical wheel washing machines" (in eighth place) were two measures that were unpopular in the field of this research. The results "High level of commitment" and "Identification of available recycling facilities" were taken as variables for this research. Last but not least, the "Use metal formwork" was considered as a variable due to the existing condition of construction projects. This is because in regards to Malaysia's construction content, timber formwork is still in use, and only large scale projects employ metal formworks. Therefore, it is significant to establish the differences of these two formworks.

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3.5.1 Use of Prefabricated Building Components

Tam (2007) stated that using prefabricated building components can seriously minimise the wastage of materials in construction. Maximising the usage of prefabricated building materials is not a new technology in the global context, but this application is still not very common in Malaysia's building construction industry. This is because contractors still choose the conventional technology since the cost of this method is lower than other methods, even though it takes more time and produces more construction waste.

Nowadays, Malaysia's construction sector is experiencing a changeover from traditional technology to more advanced mechanical systems. This new mechanism is named IBS (industrialised building system) or precast and prefabricated systems. According to Mokhtar & Mahmood (2008), prefabrication method is defined as fabricated building elements (which consist of walls, floors, ceiling, roofing, etc.) made in the factory and delivered to the construction site for installation only. This is different to the traditional way of construction in which building elements are constructed stage by stage in the project site. There are advantages to precast systems compared to traditional methods in regards to the way the construction process is off-site. Reducing the wet work during construction could reduce the manpower required for the completion of the project, thereby, producing enhanced working environments. In-situ areas normally come with large scale amounts of materials that make the implementation of waste minimisation to be even harder. Lower construction waste can be achieved with tidy, safer settings and the tiling of precast material. Besides reduced waste, precast materials are also known to have average quality and standards. Moreover, better site supervision in quality control will maximise the total

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construction cost, reduce construction time and improve natural environment issues (Tam et al., 2004). Implementing environmentally friendly construction processes to reduce the wastage of materials, such as employing precast structures and readymade elements, will encourage the increasing popularity of waste control (Ho, 2001).

Peng & Scorpio (1997) suggested that reducing the wastage of materials during construction is the best option in waste minimisation. It is the most effective way to eliminate additional waste of materials on site. Reducing cast in-situ processes in construction activities will enable a lesser effect on the environment during the construction process. The overall progress of projects can be accelerated by reducing cast in-situ time, as well as, the rapid production of precast manufacturing off-site. The parties involved can frequently cooperate in the early stage to minimise work errors. For instance, for building requirements, openings and cable pathways can be completed by manufacturing the precast panel; this means the establishing of service routes can be exempted, therefore, reducing waste generation on the construction site. Thus, using prefabrication components could minimise the waste generated in the construction industry.

It is common that the initial cost for start-up precast is higher than the conventional method of construction, but it will be cost saving in the overall construction cost due to intensive reduction in time and lesser manpower required in the precast method. Other than these direct effects, indirectly, the precast method could enhance knowledge, skills and safety in the construction sector, prompting the construction sector to minimise generated waste.

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3.5.2 Purchase Management

Purchase management is the management of purchasing material for the construction process. This management includes a study about the materials needed for construction, and provides quality management to the process of purchasing and selecting materials. The key for success in this management would be on clients; whereby, when purchasing raw materials, they must consider the factors that would lead to less waste generation, as divided in the following:

(1) Material quantity control measures to prevent extra materials ordered.

Tam (2007) stated that additional materials ordered would initially end up as waste in the construction site. Linear control measure of material quantities by progressively tracking the project status can reduce the quantum of material waste. Several research studies had proven that reducing waste volume can be attained when material quantity control is implemented in a particular construction project.

(2) Accuracy in time delivery strategy.

Tam (2007) proposed that time reduction of material storage on site can reduce the possibility of material damage due to mishandling or abuse. Applying the correct period in the delivery method can avoid excess time of stock pile incidents and cases of over-ordering materials.

(3) Supplier flexibility in providing smaller quantities of materials.

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Tam (2007) mentioned that suppliers that can provide small quantities of materials to any project could reduce the possibility of material damage due to less storage on site. Requesting suppliers to provide such services may contribute to saving costs regarding waste.

3.5.3 Education and Training

Most of the research findings commented that knowledge and induction in construction waste and the capability of reusing and recycling materials are crucial for every party involved in the construction industry. Rameezdeen (2006) agreed that education programs should be introduced to clients for knowledge input in waste management. Understanding and executing waste management will persuade them in designing environmentally friendly buildings and selecting green building products for projects.

On the other hand, education should also be introduced to labourers on the project site due to the relatively negative attitudes and behaviours regarding waste management. Generally, attitude is a settled way of thinking or feeling about something, typically one that is reflected in a person’s behaviour.

Low awareness in minimising waste generation due to lack of education and knowledge among the labourers have a significant impact on waste management. Frequent education and training should be imposed on labourers on site to change waste handling attitudes (Maycox, 2003). Kulatunga et al. (2006) further reported that continuous training and knowledge input for all construction parties is a key factor in effective waste management implementation and improvement. It was reported by Teo

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& Loosemore (2001) that attitude in waste minimisation is a huge challenge for waste management in the construction sector. Loosemore et al. (2002) stressed on the significance of behaviour in reducing material waste, and recommended that it can improve with proper education and training.

It was concluded that in this literature review, changes in attitude and behaviour towards waste minimisation via education and training is crucial for all parties involved in the construction process. Satisfaction in reducing, reusing and recycling waste can be obtained with continuous motivational influences in training for construction workers (Lingard et al., 2001). However, this research focused on refurbishment projects in Klang Valley; therefore, this conclusion shall be further proven with data analysis and findings in this study.

3.5.4 Proper Site Layout Planning

In a project, the layout planning before construction takes place is important because storage materials should be centralised for all work to be carried out in that particular site. Sauders & Wynn (2004) agreed that with proper layout planning in construction sites, waste can be minimised by reducing the travel distance of materials to the other portion of the construction site. For example, waste from mixing concrete will greatly reduce due to the time and distance travelled. Therefore, it is important to identify that the stored materials are not far away from the point of application. Negligence in planning during the design stage, such as a lack of consideration in waste reduction, will usually result in extra construction materials. Moreover, improper storing methods also lead to waste generation in construction. Concerning storing methods, inappropriate site storage space is one of the reasons that lead to damage or deterioration of materials. As a result, waste is generated and this will affect the total cost of the project due to the replacements of damaged materials. The other factors that cause waste generation due to improper site layout planning are:

I. Lack of on-site waste management plans.
II. Delays in passing information on types and sizes of materials and components to be used.
III. Lack of on-site material control.
IV. Lack of supervision.
V. Poor coordination and communication (late information, last minute client requirements, slow drawing revision and distribution).
VI. Transportation due to damage during conveyance.
VII. Insufficient protection during unloading.
VIII. On-site transportation methods from storage to the point of application.

3.5.5 On-site Waste Recycling Operations

Malaysia's construction sector is responsible for producing various types of waste during construction; especially in major infrastructures, commercial, housing and other highly demanded construction activities. Faniran & Caban (1998) stated that the availability of waste management in the market is basically a classic way of implementing the waste management hierarchy, which is arranging the stage level of waste management choices, waste central control, waste reduction, waste reusing, waste recycling and waste dumping.

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Lauritzen (1998) noted that 80-90% of construction waste can be recycled and reused. In addition, the recycling method is simple to carry out, and is cost effective for the entire project. The financial advantages of waste minimisation and the recycling process are the probability of reselling certain waste (such as steel bars, papers and woods), or disposing the waste from site at no cost. Otherwise, cost will be incurred as these wastes may end up in landfills (Snook et al., 1995). Despite the benefits mentioned above, Lam (1997) pointed out that less parties are providing initiatives for environmental impact or even imposing the recycling of construction materials due to their priority of completing and handing over the project in the fastest time frame. As a result, implementation of waste management is neglected and rarely focused upon.

The additional generation of waste, incorrect waste management and little consciousness of the necessity for reducing waste are normal in the construction sector (Begum, 2005). The 3R concept (reduce, reuse and recycle) has been promptly advertised to the construction industry to create a sustainable environment. Many supported researches in waste management options show that on-site recycling operation is the current focus due to less or no cost incurred (Denison & Ruston, 1990). Overall, the on-site recycling operation seems to be a popular and effective way for waste minimisation because it is easy to implement and lowers cost. However, this research had focused on refurbishment projects, therefore, this conclusion shall be further proven with data analysis and findings from this study.

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3.5.6 High Level Management Commitment

According to Tam (2007), the owners and end users will always allocate a cost for a waste management system in their budgeting and standard guidelines for project requirements. This allows the tenderer to refer to this information so as to assist in the implementation of waste management processes on site. The tenderer emphasises that if the clients agree to implement waste management in a project, environmental caution for construction industry can be a priority; this means that the wastage of materials can be greatly reduced when high level management is committed to achieving waste minimisation targets. However, there are some surveys that reported that the cost for implementing waste management is a burden. On the other hand, there are some researches that had mentioned that large parties in the construction sector are enthusiastic in implementing waste management as it can provide good social responsibility for the company.

In order for companies to minimise and reduce the impact of their activities on the environment, construction parties have developed comprehensive strategies that can bring negative reputations to the lowest (Johnson & Scholes, 1993). The success of waste implementation of an organisation can be measured by cost performances, but the success of the implementation is not dependent on short-term profits only. The success must be recognised by the company, and it must have value added to the shareholders.

All parties involved in construction must agree that every single activity accomplished on site has an effect on nature. Several possibilities are accessible to reduce harm on the environment, and further contribute to sustainable environmental goodness.

However, continuous refinement in environmental performance becomes hard and expensive. Proper planning in waste management is crucial to minimise the risks taken by construction organisations when implementing the system. Immediate values related to energy inefficiencies, material wastage, pollution and low publicity will generally influence the environment's sustainable goodness.

Sustainable construction can be achieved by contract agreement between the client and the contractor. The client's 'go green' vision in construction is crucial to encourage the contractor to enhance corporate image, as well as, overall project cost (Ofori & Chan's, 1999). Researchers reported that there are no accurately quantified or measured data of actual affect and impact on corporate image for those that had implemented waste management systems in construction projects. Despite saying so, the enforcement of regulations on environmental departments have significantly reduced pollution and environmental degeneration. On top of that, the establishment of Environmental Impact Assessment in the Environmental Quality Act, 1974 for construction has driven the growth of responsibility in Malaysia. Public requests for better environmental performances affect the contributions given by stakeholders in construction parties.

Based on the above information, high level management should pay more attention to waste reduction implementation. Several types of variables that influence the performance of projects will be further discussed.

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3.5.7 Identification of Available Recycling Facilities

Reducing waste from construction materials by adopting effective recycling will facilitate significant benefits to society. Lingard et al. (2000) mentioned that a community advantage would entail staying away from establishing unwanted landfill locations, which will allow the possibility of health risks to the environment, depositing hazardous materials on the earth.

Therefore, one recycling method is cooperation with suppliers. The existing low level of market establishments had affected the time and money invested in relationships; therefore, partnership can reduce the excess of materials that occur, as well as, reconciliation and reuse. In such practices, financial incentives normally propel the waste minimisation process. Most suppliers will identify and establish a connection with contractors, and partner with them by promoting the recycling business as an alternative way for waste disposal during construction.

3.5.8 Use of Metal Formwork

In Malaysia’s construction industry, most formwork used is the timber formwork. Although timber formwork has lower initial cost than the metal formwork, its life cycle is shorter, with less durability than the metal formwork. In the long run, metal formwork is the more economical choice. After the timber formwork is used 2-3 times, it will start to decay and become soft. Hence, the timber formwork will no longer serve its function, becoming waste material. Reducing waste material in construction seems to be one of the best solutions (Peng & Scorpio, 1997).

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As commonly known, reduction is the ideal method in minimising the wastage of materials and removing most of the waste disposal difficulties. The metal formwork employed can be recycled and reused again and again. Thus, waste can be reduced. The reuse of metal formworks may have its own limitation. Every building design is unique and not every metal formwork design can be altered to suit the project; as a result, additional cost will be needed to acquire new metal formworks, as well as, making modifications.

All researches have agreed that introducing metal formwork systems in construction sites would result in fewer timber formwork and fewer waste generation on site, which is a value added to the environment. The merits from this implication would be the reduction of water and noise pollution, and enhancements in waste management and waste discharged. However, this research focused on refurbishment projects, therefore, this conclusion shall be further proven by the data analysis and findings of this study.

3.6 Summary

From the above statement, the significant reasons that drive waste generation in refurbishment are those related to the conventional construction method, poor workmanship, poor storage, mishandling, disorderly construction sites and ineffective management techniques. The barriers of waste management implementation are generally greater compared to other construction issues; prioritising the importance of waste minimisation is relatively low. This research can be a reference in documenting waste management standard policy in Malaysia's refurbishment field. However, the reference is limited since this study focused on the refurbishment project in the Klang Valley region. The following chapter will discuss the overall research design.

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CHAPTER 4

RESEARCH METHODOLOGY

4.1 Introduction

Methodology is an important element in this research project. It refers to the way a researcher will conduct his work. This chapter presented the rationale for the research method employed in this study, which was sufficient to obtain the relevant data for scientific evaluation. A research methodology is a layout that guides the data collection and analysis processes of the research project. It is the backbone that indicates which types of information are to be acquired, the sources of the data process and the approach of the data collection. An approach must be accomplished in an organised, orderly, consistent and easy way to be understood by other readers, so they may fully comprehend the information.

Every problem and complication in a dissertation research must be arranged correctly to create a helpful and formulated questionnaire that will achieve the objectives in the study. An effective methodology will meet the standards in providing solutions to the problem statements. The primary function in this chapter was to discuss the research population, sample, the instruments used for measuring the various variables in the research design, the data collection process, data analysis, the statistical analysis of the quantitative study, as well as, to measure the research findings so as to lead to valid conclusions.

According to Neuman (2000), the quality, reliability and validity of the conducted research exceedingly depends on how robust the implemented research methodology

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is. Overall, the research methodology is used to notify the what, why, when, where, who and how to question the respondents regarding the study.

Four sections were presented in this chapter: the research design, identification of population, the data collection method and the data transformation.

The main objectives of this chapter are as follows:

a. To explain the data collection process.
b. To explain limitations governing the sample survey.
c. To describe the statistical techniques used for the data analysis.

4.2 Research Design

Krippendorf (1980) noted that a research design is a procedural network of analytical steps through which information is processed. The research design provides researchers with an account of what the data are, the reasons why the data were collected and the methods of analysis used. It also provides a guideline on what should be done to the data collected so that it could provide evidence to support the research objectives set out in the early part of the study.

Krippendorf (1980) further explained that there are three main purposes of the research methodology:

a. To describe and examine the logic of the composition of the research methods.
b. To find domains of appropriate application and predict possible contributions to knowledge.

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c. To reveal the limitations and scope of the study.

Validity in the research is about the strength of the research conclusions, inferences or propositions. Cook & Campbell (1979) defined it as the best available approximation to the truth or falsity of a given inference proposition or conclusion. Investigation, if it is conducted correctly, could obtain a better understanding of the relationship between a hypothesis set and a particular phenomenon of theoretical or practical interest. One of the main difficulties identified was to select which research methodology is the most suitable for use. However, Howard (1985) noted that studies that test the adequacy of the research method does not prove which technique is better, it only provides evidence relating to the potential strengths and limitations of each approach.

Research may be quantitative or qualitative in nature. This study adopted the quantitative approach because reality may be captured and translated into the form of statistical analysis. According to Sarantakos (1988), quantitative research refers to research that is based on principles of methodology that employs quantitative measurements and statistical analysis; whereas, the qualitative approach refers to several methodological approaches that employ non-qualitative data collection which describes the reality as experienced by the respondents. The objective of employing the quantitative method is to minimise personal prejudice or bias, and to ensure that the social reality would be presented as it is. It is expected to have true value, applicability, consistency and conformability (Guba & Lincoln, 1989).

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The general data collection techniques for quantitative research are secondary data sources, objective measures or tests, semi-structured interview questions and structured survey questionnaires. The data collection techniques adopted for this study were secondary data sources and surveys. Data is generally divided in two categories: primary and secondary. Primary data is collected specifically for the research needs at hand. Secondary data is already published data collected for purposes other than the specific research needed at hand. There are various secondary data sources that have been consulted that are related to the research topic and needs; such as, books, reports, journals, articles in academic journals, conference papers, brochures, pamphlets, website libraries (CAIS), internet databases, etc. The secondary data used should also be from recognised authors and should reflect quality information. The information of data was evaluated and analysed to establish a better understanding of the nature of this research.

Measurements on the different variables that contribute to waste in refurbishment projects were identified and developed. Questionnaires were used as a tool to gather the required data in this study. The collected data were analysed using quantitative statistical analysis package software. The correlation tests between the dependent, intervening and independent variables determined the relationships among the group of variables shown in the theoretical framework. The study also provided an understanding on the factors that contribute to waste in refurbishment projects. Figure 4.1 displayed the research design employed in this study.

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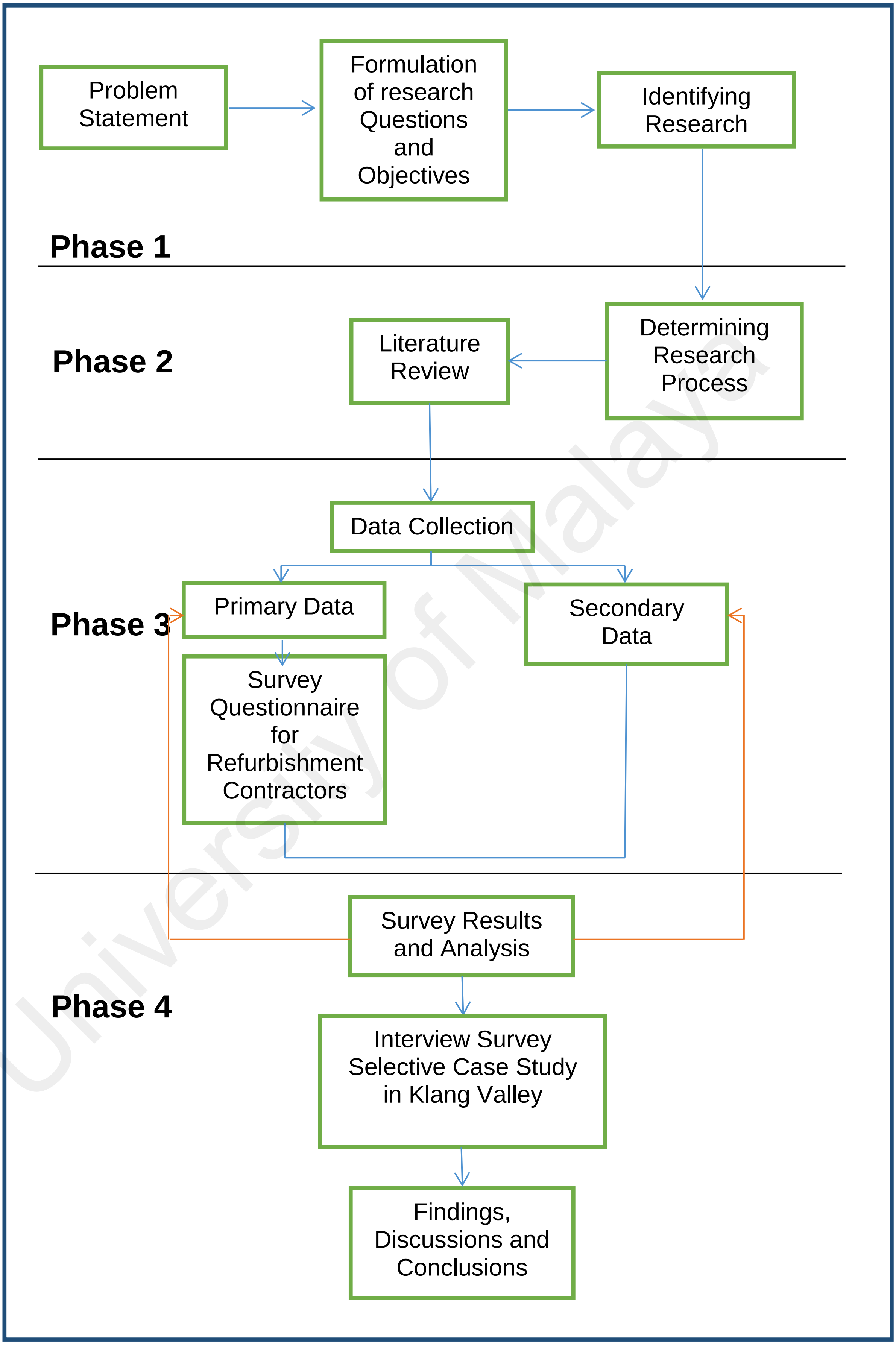

Figure 4.1: Research flow chart

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Based on **Figure 4.1**, there are 4 phases in this research.

Phase 1

The research project began with the problem statement. This was followed by the formulation of research questions and objectives. And finally, the research scope was identified and selected in this study.

Phase 2

Determining a research process is an important element, whereby, it refers to the way a researcher will accomplish his work. This process must be done in a systematic manner, practical and can be easily interpreted. This is later followed by literature reviews. It is important for researchers to fully understand what is being researched, and to further look at previous studies conducted by other researchers.

Phase 3

This phase involves the data collection, whereby, it is important to know what types of data is needed and how to collect such data. Lastly, would be how to analyse the collected data.

Phase 4

Before proceeding to the finding stage, the result summary from the questionnaires are verified through the interview surveys from selective correspondences to ensure that the questionnaires conducted are relevant to this research. After verification, the next step is acquiring the findings, and lastly, drawing out the conclusion for the study that

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must fulfil the research questions, objectives and research scope predetermined in the previous phases.

4.2.1 Identification of Research Population and Numbers of Respondents

It is vital to identify a relevant research population, as well as, a certain number of respondents that reflect the true picture of the study. This research focused on how waste is being generated and how to minimise waste in refurbishment projects; hence, the appropriate research population target would be contractors. The reason why contractors were selected as the research population was because this population group has direct exposure to operations during construction projects. The research population "Contractor" selected in this study referred to CIDB registered contractors involved in refurbishment projects, starting from year 2012 and ending within year 2014.

The Population is the group of objects or people with the needed attributes that are concentrated upon in a research (Mahamood, 1992). Klang Valley was chosen as the seating ground for this research. Thus, the research population of the study was contractors that work in the area of Klang Valley.

Respondents for the present study consist of contractors who are registered with CIDB and were involved in refurbishments from year 2012 to year 2014. According to the information given by CIDB Construction Statistics Department, there were a total of 191 refurbishment projects of Grade G7 (CIDB) due to no limitation in project size and hence more material involved and relevant to the waste generation.. All 191 respondents from each project were targeted with a questionnaire; the number of respondents was sufficient to reflect on the actual picture in this study. The total

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number of questionnaires was achievable, therefore, the researcher decided that the questionnaires should target all 191 respondents, and the data were analysed in this study.

4.3 Research Instrument

Questionnaires are a written set of reformulated questions that require the respondents to record their answers. Questionnaires were designed and distributed among the selected sample of respondents that met the criteria mentioned above (contractors registered with CIDB). 2 sets of 5 point ‘Likert Scales’ were used for faster and more precise data plotting by respondents, where the respondents are required to record their answers on the 5 anchors. The first set of 5 points are: strongly agree (5), agree (4), neutral (3), disagree (2) and strongly disagree (1). The second set of 5 points are: very important (5), important (4), neutral (3), unimportant (2) and least important (1). The questionnaires were distributed to respondents that met the said requirements.

One hundred and ninety-one (191) respondents were involved in the questionnaire survey. The respondents were selected based on their experiences in refurbishment projects from years 2012 to 2014. This was due to the questionnaires being carried out within that period. Moreover, to ensure the validity of the respondents, three requirements were present before commencing with the questionnaire:

1. The project began after year 2012 and completed before year 2014.
2. The project must be more than RM500,000.00.
3. Respondents must answer based on the refurbishment project.

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The questionnaire was printed on white coloured paper, and was distributed manually to contractors. A sample of the questionnaire was shown in Appendix A.

The questionnaire consisted of several parts. In Part 1, two (2) questions, considered as demographic questions, included the personal details and background of respondents. The demographic information is to ensure that the respondents are psychologically comfortable while answering the questionnaire. Such questions will help the researcher establish a better understanding of the background of respondents, which will better reflect the nature of this paper.

In Part 2, the questions were related to the project characteristics. In this part, the questions target the project that was accomplished by respondents so that the researcher will have a better understanding on the completed projects. Besides that, this part also consisted of questions regarding the duration and cost of the projects, which will aid the researcher in gauging the performance of the projects. In Part 3 of the questionnaire, the questions were related to the causes of waste generation, which were vital to this study. A total of sixteen (16) variables were listed in the questionnaire. The respondents had to answer the questions on a 'Likert Scale’ which was: strongly agree (5), agree (4), neutral (3), disagree (2) and strongly disagree (1). In Part 4, the questions were related to waste minimisation, which was also crucial for this study as well. A total of eight (8) variables were listed in the questionnaire. The respondents had to answer the questions on a Likert Scale which was: least important (1), less important (2), neutral (3), important (4) and very important (5). For the last part of the questionnaire, the questions were related to the dependent variable of the study which was the performance of the project.

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Table 4.1: The Questionnaire Survey

Description	**Frequencies**
Number of questionnaires distributed	191
Questionnaire sets returned without answers	10
Questionnaires answered, but were rejected	9

From 191 questionnaires, 10 sets were returned without answers as the contractors had refused to participate due to personal reasons; and 9 respondents were rejected because of not following the instructions given on the questionnaire, as well as, providing incomplete answers. The detailed analysis and results were presented in Chapter 6.

4.4 Data Analysis

Data analysis is the most important part of a research, obtaining accurate and relevant information that are appropriate for the study. Data collected from different sources, either primary or secondary data, were accessed in this stage by applying appropriate statistical tests. These statistical tests usually determine the outcome and overall conclusion of the findings. Methods that were applied in this study included Descriptive Statistics (frequency and cross tabulation), Mean, Reliability Test and Correlation (Spearman). All collected data were analysed through the Scientific Package for Social Package (SPSS) version 16.01, which is a sophisticated software for statistical analysis. SPSS was chosen because it is easier to assess the data.

4.4.1 Descriptive Statistics

After the values or scores on some variables have been collected, one of the tasks of the researcher is to describe the scores. This information, along with the process conducted, are called descriptive statistics (Wiersma, 1991). According to Fraenkel &

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Wallen (1993), descriptive statistics enable the researcher to describe data with numerical indices, as well as, organise and reduce large numbers of observations.

Heiman (1992) described statistics as procedures for organising and summarising the data in order to communicate and describe the important characteristics of a sample. The findings of the data are in numerical form, such as the demographic questions and closed-ended questions; and the Likert Scale is usually reported in the form of distribution, mean or standard deviation.

4.4.2 Mean

According to Barrow (2001), the mean or the arithmetic mean is commonly known as the average. It is the most obvious measure of location, and is obtained simply by adding all the observations and dividing by the number of observations. In this study, the mean was used to measure the central tendency of the respondents' answers, and to determine which sales promotion tools are likable.

4.4.3 ANOVA

ANOVA is the short form for Analysis of Variance. It is a statistical technique to acquire variety between two or more means. The ANOVA analysis compares the means in the research to see whether they are significantly different from each other. It is a convention of placing the large sample variances in the analysis to determine if different levels of waste minimisation affect the measures in refurbishment projects.

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4.4.4 Correlation

Correlation measures how variables are related. Pearson's correlation coefficient assumes that each pair of variables is bivariate normal and it is a measure of linear association. Two variables can be perfectly related, but if the relationship is not linear, Pearson's correlation coefficient is not an appropriate statistic for measuring their association (Wiersma, 1991).

The correlation table displays Pearson correlation coefficients, significant values and the number of cases with non-missing values (N). The values of the correlation coefficient range from -1 to 1. The sign of the correlation coefficient indicates the direction of the relationship (positive or negative). The absolute value of the correlation coefficient indicates the strength, with larger absolute values demonstrating stronger relationships (Wiersma, 1991). The correlation coefficients on the main diagonal are always 1 because each variable has a perfect positive linear relationship with itself (Wiersma, 1991).

The significance level (or p-value) is the probability of obtaining results as extreme as the one observed. If the significance level is very small (less than 0.05) then the correlation is significant and the two variables are linearly related. If the significance level is relatively large (for example, 0.50) then the correlation is not significant and the two variables are not linearly related.

4.4.5 Reliability Test

The reliability test was used to identify the reliability level of the data collected through the questionnaires that were distributed to respondents. Reliability is concerned with the stability and consistency with which the instrument measures the concept. The test ensures that the measurement is free from random or unstable errors. Reliable instruments must be robust; working well under various conditions and at all times.

The reliability test refers to the Cronbach Alpha. Fraenkel & Wallen (1993) stated that it is used to check the internal consistency of an instrument. If the coefficient alpha is near to +1, the questionnaire would be more reliable. The reliability should be more than 0.70 and preferably higher for research purposes (Fraenkel & Wallen, 1993). The questionnaire is considered reliable and valid because it will produce the same results each time it is administered to the same respondents for the same reasons.

4.5 Summary

The above-mentioned research methodology was implemented in achieving relative results and objectives. It highlighted how the literature reviews and questionnaires were administrated. Moreover, it extensively described how the research was prepared and executed. The thesis framework was broadly standardised with contents comprising of problem statements, literature reviews, research methodology, data analyses, findings, and lastly, research conclusion.

Research was accomplished by using the main component and secondary data resources of the surveys. Then, quantitative analysis was carried out on the received feedback data. There was a total of 172 relevant and final data out of the planned 191 respondents. After the quantitative analysis, the qualified data obtained were analysed by using statistical tools, SPSS. The design of the questionnaire to collect data from respondents was also touched upon at great length. Moreover, the researcher had

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conducted interviews on randomly selected respondents to ensure they are relevant to this research before entering the findings stage. In the following chapter, a detailed discussion on the data analysis was provided.

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CHAPTER 5

ANALYSIS AND FINDINGS

5.1 Introduction

This chapter discussed the results of the data analysis of 172 questionnaires regarding waste generation factors and effectiveness of waste minimisation in refurbishment projects within Klang Valley. The data collected by the questionnaires were analysed using the Scientific Package for Social Sciences (SPSS) version 16.01. The significant variables were identified, and this chapter presented the results and analysis obtained from the questionnaires survey. This will provide more information and understanding regarding the results, and answers the question of whether the hypothesis should be accepted or rejected.

Table 5.1: The Questionnaire Survey

Description	Frequencies
Number of questionnaires distributed	191
Questionnaire sets returned without answers	10
Questionnaires answered, but were rejected	9

From 191 questionnaires, 10 sets were returned without answers because the contractors had refused to participate due to personal reasons. Another 9 respondents were rejected because they did not follow the instructions given, and some had provided incomplete answers. With simple calculations, the researcher summarised the response rate as 80%.

5.2 Respondents' Backgrounds

The research focus emphasised refurbishment projects that began from year 2012 and were completed before year 2014 in order to measure the waste generation factors and waste minimisation.

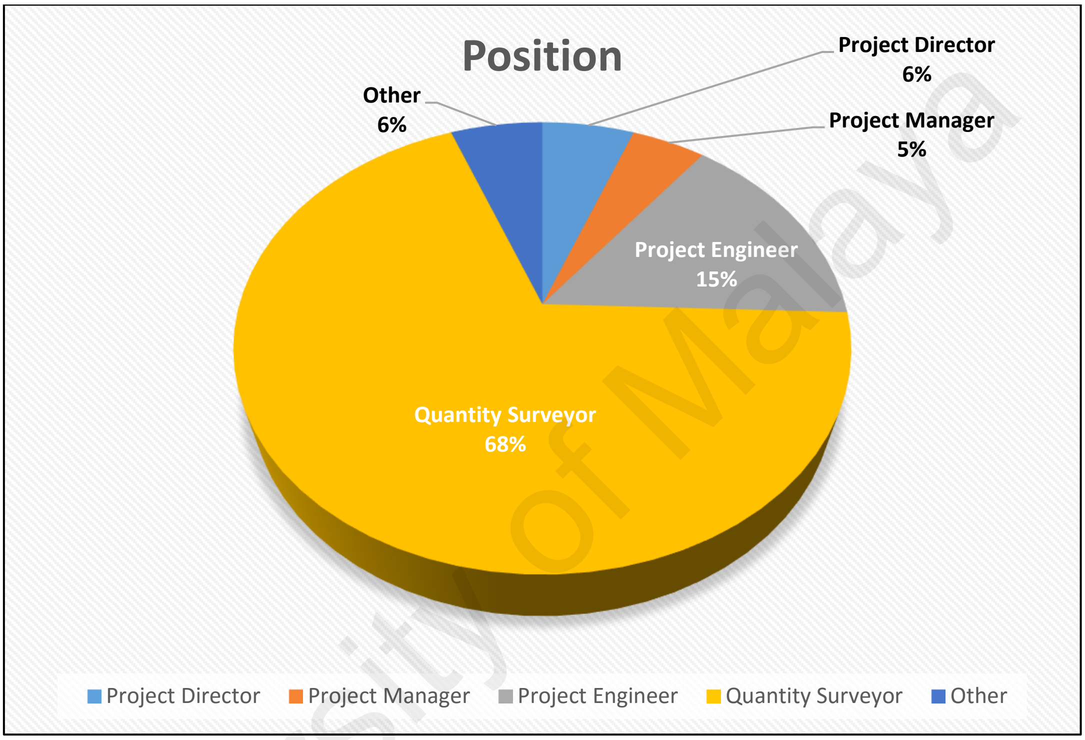

Figure 5.1: Position in refurbishment projects

From Figure 5.1, the majority (68%) out of 172 respondents occupy the quantity surveyor position. The second largest group was project engineer which contributed 15%. The third included project director (6%), as well as, the 'other' position (such as supervisors, safety officers, etc.) which also made 6% as well. The last was project manager with only 5% from 172 respondents. Quantity surveyors were the major position in this survey. This was beneficial since the performance was measured by cost. Quantity surveyors are the contract people in the project, and this particular group possesses the most reliable outgoing cost data in the project. Besides that, quantity surveyors have better knowledge of how waste affects the cost of a project. With this variety of respondents, the researcher believed it would produce a reliable result for this study.

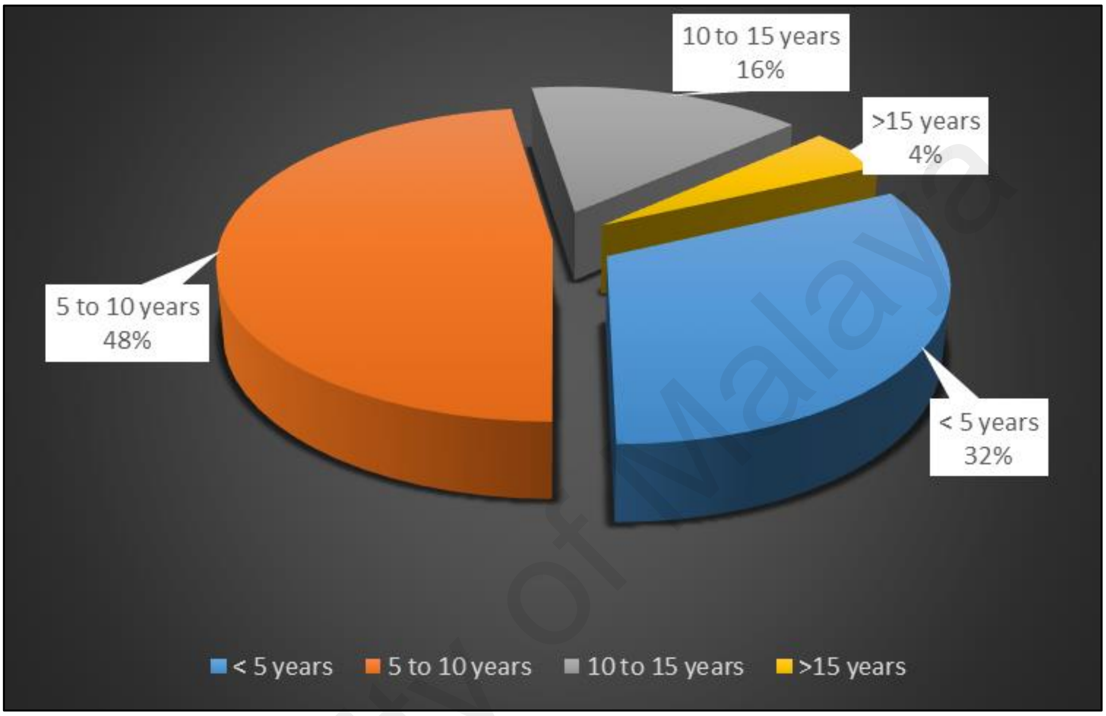

Figure 5.2: Experience in refurbishment

Figure 5.2 presented the baseline estimation of the differences of experiences regarding refurbishment projects for the 172 respondents. In total, the majority (48%) of respondents have 5 to 10 years of experience, 32% have less than 5 years of experience, 16% are in between 10 to 15 years of experience and 4% have more than 15 years of experience in refurbishment projects.

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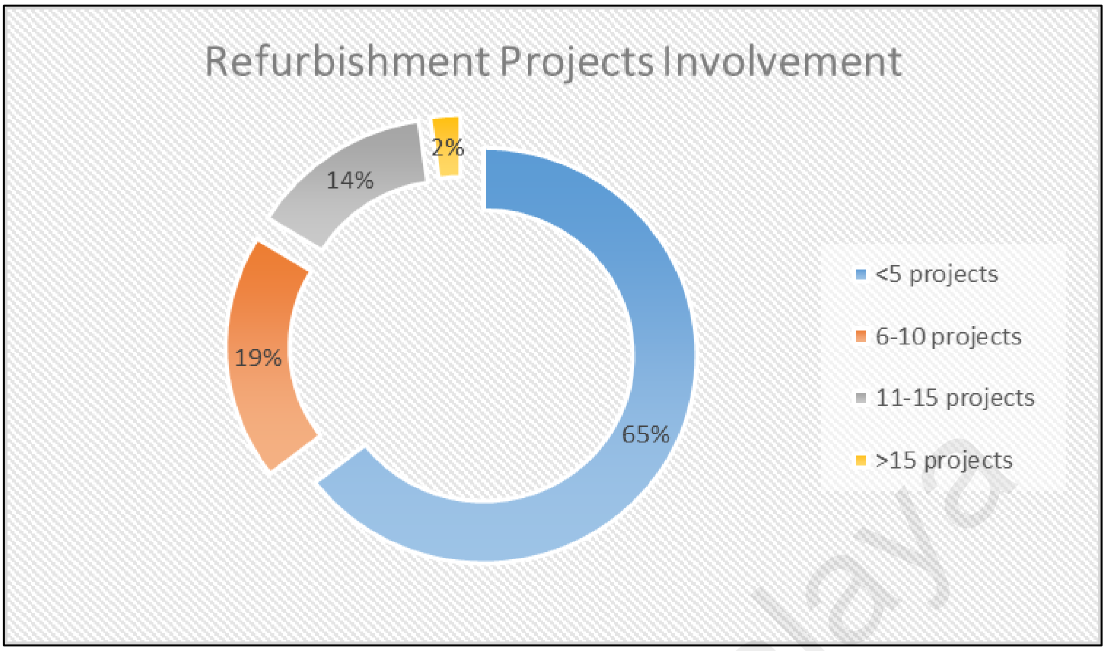

Figure 5.3: Refurbishment projects involvement

Figure 5.3 illustrated the different number groups of refurbishment projects that the respondents have been involved in. Most respondents conducted less than 5 projects. This indicated that the average of each refurbishment project is 2 years if compared with the respondents' refurbishment experiences. 19% was second in place where respondents had conducted between 6 to 10 projects, followed by 14%, where 11 to 15 projects were conducted. Last but not least, 2% of respondents had accomplished more than 15 projects.

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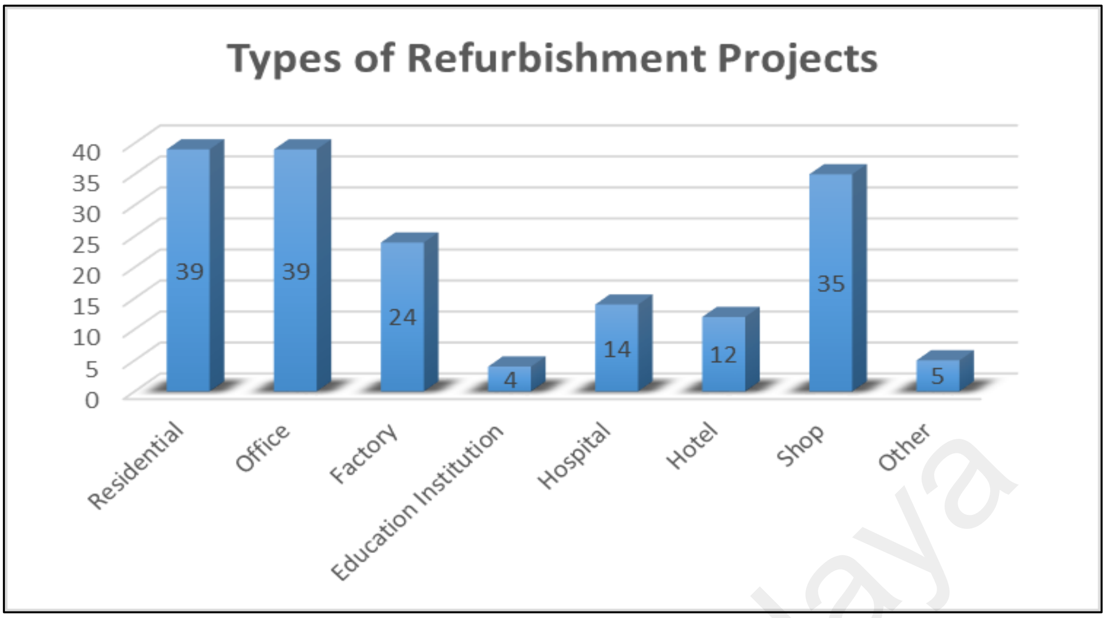

Figure 5.4: Types of refurbishment projects

Figure 5.4 displayed the numbers of refurbishment projects in various industrial buildings within the survey. The figure provided information for readers to obtain a clearer picture as to what type of refurbishment projects were considered in this research; such as residential, offices, shops, etc. Residential, office and shop categories are the majority in this survey. The "other" category included shopping malls, community halls and temples.

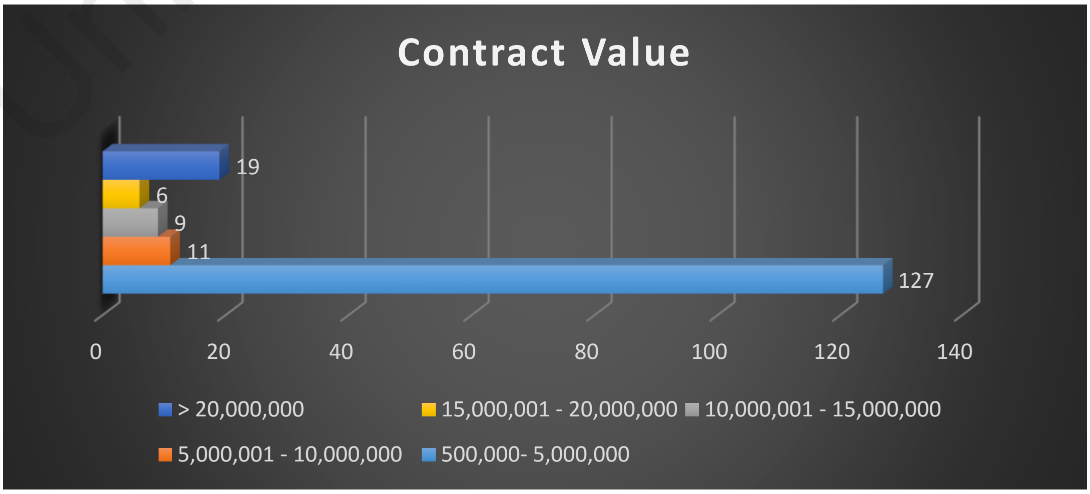

Figure 5.5: Contract value of selected projects

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Figure 5.5 indicated the level of contract value of refurbishment projects. The majority of 127 respondents in this survey fell between RM500,000-5,000,000 contract values. The high numbers in these contract values were mostly from refurbishments of residential, offices and shops. The second highest included 19 respondents with more than RM20,000,000 contract values, which mainly consisted of shopping malls, hotels and factories; followed by the third highest with 11 respondents having between RM5,000,001 to RM10,000,000 contract values. This was then followed by 9 respondents who possessed between RM10,000,000-15,000,000 contract values. The lowest number (6 respondents) had between RM15,000,001 to RM20,000,000 contract values.

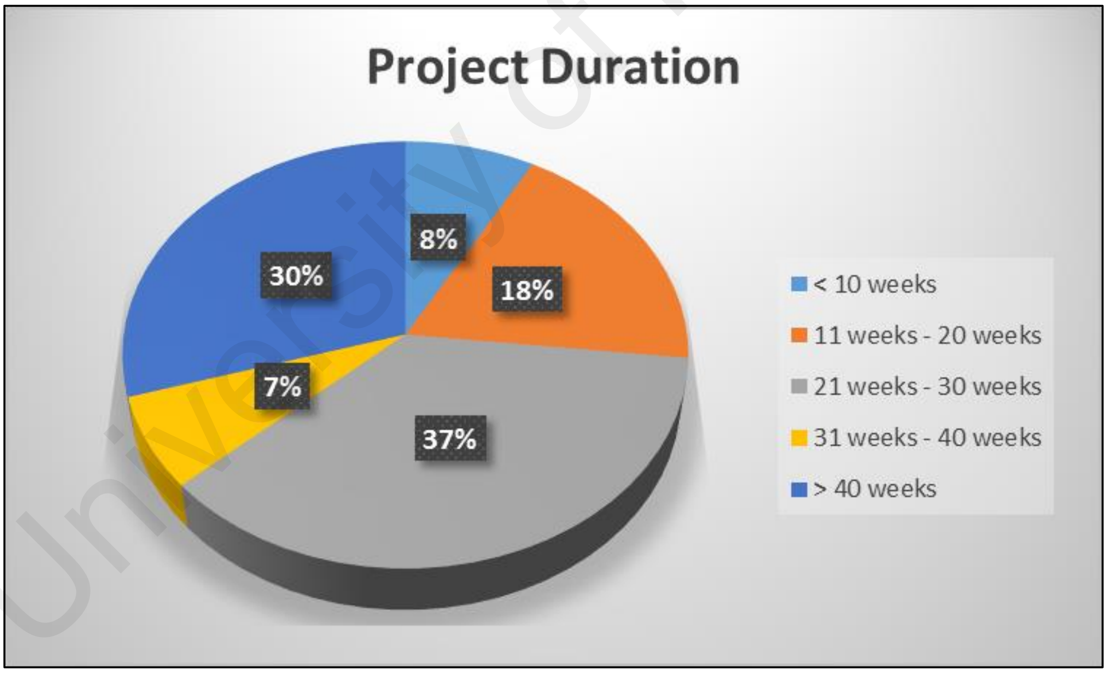

Figure 5.6: Project duration

Figure 5.6 indicated that 37% (the majority) of projects were completed between the duration of 21-30 weeks, and this is considered as the normal time frame for refurbishment project completion. The second highest (30%) fell in more than 40

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weeks in duration. The third highest was 18%, where projects were completed between 11-20 weeks, followed by 8% in which projects were finished in less than 10 weeks. Lastly, only 7% of projects were completed in the duration between 31-40 weeks.

5.3 Correlations

In this section, the relationship between waste generation factors with variation orders (VO) and waste ratio of the project (according to the survey) was analysed. The method to accomplish the relation was with the use of Correlations in SPSS 16.0.1. The following tables summarised all the correlations between the variables with VO and waste ratio.

Table 5.2: Correlations between variables and cost

Variables	VO	Waste Ratio
Design Change	-0.093	0.079
Design Errors	-0.011	-0.018
Lack of Design Info	-0.163*	0.221**
Wrong Material Storage	-0.032	0.062
Poor Material Handling	-0.003	-0.122
Damage During Transportation	0.068	0.163*
Poor Material Quality	0.044	-0.060
Equipment Failure	0.103	0.069
Poor Site Management	0.164*	0.037
Poor Controlling	0.148	0.015
Poor Supervision	0.088	0.257**
Inappropriate Construction Method	0.100	-0.201**
Lack of Coordination	0.119	0.172*
Scarcity of Equipment	-0.161*	0.071
Leftover Materials	-0.057	0.011
Ordering Errors	-0.002	-0.035

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

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Table 5.3: Correlations between design change with VO and waste ratio

Correlations				
			VO	Waste Ratio
Spearman's rho	Design Change	Correlation Coefficient	-.093	.079
		Sig. (2-tailed)	.224	.302
		N	172	172

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

According to one of the interviews, Mr. A who is the Project Manager from Company X, stated that the design changes in this context are the amendments of design during the construction stage. From the analysis, there is no significant value in the correlation between design change with VO and waste ratio.

Table 5.4: Correlations between design error with VO and waste ratio

Correlations				
			VO	Waste Ratio
Spearman's rho	Design Errors	Correlation Coefficient	-.011	-.018
		Sig. (2-tailed)	.886	.816
		N	172	172

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Table 5.4, the correlations analysis, demonstrated that there was no significant value between VO and waste ratio. According to a Project Manager in Company Y, from their own experience and with the assistance of consultants, design errors are not significant in contributing waste.

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Table 5.5: Correlations between lack of design information with VO and waste ratio

Correlations				
			VO	Waste Ratio
Spearman's rho	Lack of Design Info	Correlation Coefficient	-.163*	.221**
		Sig. (2-tailed)	.033	.004
		N	172	172

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

According to Table 5.5, the lack of design information has a significant value on the waste ratio and VO. The result was 0.221, two stars ** significance at 99%, and -0.163 one star *, respectively. This means that the waste ratio is very dependent on design information in refurbishment projects. According to a Contract Manager from Company Y, the refurbishment contractor for The Mall, there are several factors that contribute to such a result. Firstly, it is due to insufficient design information given to contractors, therefore, the related work must be postponed and delayed. Secondly, reconstruction work takes place when the construction drawings are issued late. On the other hand, the VO result was due to construction drawings not being clearly specific regarding the scope of work. The demarcation information is insufficient for clients and contractors during tendering, and also during the construction period.

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Table 5.6: Correlations between wrong material storage with VO and waste ratio

Correlations				
			VO	Waste Ratio
Spearman's rho	Wrong Material Storage	Correlation Coefficient	-.032	.062
		Sig. (2-tailed)	.678	.420
		N	172	172

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

From Table 5.6, there was no significant value between wrong material storage with VO and waste ratio. Wrong material storage, in this context, means that inappropriate material storage had no significant value on the VO and waste ratio.

Table 5.7: Correlations between poor material handling with VO and waste ratio

Correlations				
			VO	Waste Ratio
Spearman's rho	Poor Material Handling	Correlation Coefficient	-.003	-.122
		Sig. (2-tailed)	.971	.111
		N	172	172

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

From Table 5.7, there was no significant value between wrong material handling with VO and waste ratio.

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Table 5.8: Correlations between damage during transportation with VO and waste ratio

Correlations				
			VO	Waste Ratio
Spearman's rho	Damage During Transportation	Correlation Coefficient	.068	.163*
		Sig. (2-tailed)	.128	.031
		N	172	172

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

From Table 5.8, there was a significant value of 0.163* between damage during transportation and waste ratio, but not with VO. Damage during transportation is mostly due to site accessibility in refurbishment projects. According to a Project Director from Company Z, poor accessibility in refurbishment projects had caused a lot of wastage. He added that wet work such as concrete must be made on site.

Table 5.9: Correlations between poor material quality with VO and waste ratio

Correlations				
			VO	Waste Ratio
Spearman's rho	Poor Material Quality	Correlation Coefficient	.044	-.060
		Sig. (2-tailed)	.569	.432
		N	172	172

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Table 5.9 indicated that there was no significant value between poor material quality with VO and waste ratio.

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Table 5.10: Correlations between equipment failure with VO and waste ratio

Correlations				
			VO	Waste Ratio
Spearman's rho	Equipment Failure	Correlation Coefficient	.103	.069
		Sig. (2-tailed)	.181	.369
		N	172	172

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

From Table 5.10, there was no significant value between equipment failure with VO and waste ratio. Equipment failure in refurbishment projects include backhoe, tower crane, concrete mixers, hackers, pumps, etc. According to Mr. A, the Project Manager from Company X, equipment failure has only little impact on VO and waste ratio in projects.

Table 5.11: Correlations between poor site management with VO and waste ratio

Correlations				
			VO	Waste Ratio
Spearman's rho	Poor Site Management	Correlation Coefficient	.164*	.037
		Sig. (2-tailed)	.031	.631
		N	172	172

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

From Table 5.11, poor site management has a significant value on VO, but not on the waste ratio. According to an interview session with Mr. C, the Project Director from Company Z, poor site management is the lack of construction managerial experience

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by the project team. Lack of managerial experience will directly lead to VO works in refurbishment projects.

Table 5.12: Correlations between poor control with VO and waste ratio

Correlations				
			VO	Waste Ratio
Spearman's rho	Poor Control	Correlation Coefficient	.148	.015
		Sig. (2-tailed)	.052	.840
		N	172	172

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

From Table 5.12, there was no significant value between poor control with VO and waste ratio.

Table 5.13: Correlations between poor supervision with VO and waste ratio

Correlations				
			VO	Waste Ratio
Spearman's rho	Poor Supervision	Correlation Coefficient	.088	.257**
		Sig. (2-tailed)	.253	.001
		N	172	172

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

From Table 5.13, poor supervision has the same nature with poor site management, in which it is significant to the waste ratio but not to VO. According to Mr D from Company W, lack of site supervisory experience will lead to poor control in

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workmanship quality. Thus, extra materials will contribute to the wastage of those materials.

Table 5.14: Correlations between inappropriate construction methods with VO and waste ratio

Correlations				
			VO	Waste Ratio
Spearman's rho	Inappropriate Construction Methods	Correlation Coefficient	.100	-.201**
		Sig. (2-tailed)	.190	.008
		N	172	172

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

From Table 5.14, it was proven that inappropriate construction methods have a significant value on waste ratio. It shows two stars ** at a significance of 99% for the waste ratio. Poor construction methods will lead to the failure of buildings and structures; hence, construction of the same work must be rectified and repeated. This would interrelate with the lack of coordination of work due to not submitting or following any method statement. Hence, a wrong construction method is significant to waste ratio.

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Table 5.15: Correlation between lack of coordination with VO and waste ratio

Correlations				
			VO	Waste Ratio
Spearman's rho	Lack of Coordination	Correlation Coefficient	.119	.172*
		Sig. (2-tailed)	.120	.024
		N	172	172

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

From Table 5.15, lack of coordination had a significant value to waste ratio but not to VO. From the interview with the Project Manager for Company X, lack of coordination between the project site team tends to increase the wastage of materials in construction. Especially regarding coordination between headquarters and site personnel, instruction or vision is not properly channelled down. Hence, it causes contractors to bear with rectification and reconstruction works.

Table 5.16: Correlations between scarcity of equipment with VO and waste ratio

Correlations				
			VO	Waste Ratio
Spearman's rho	Scarcity of Equipment	Correlation Coefficient	-.161*	.071
		Sig. (2-tailed)	.035	.353
		N	172	172

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

From Table 5.16, scarcity of equipment had a significant value for VO only. For example, undersupply of levelling pad equipment in contracts will cause rework due

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to uneven surfaces or floors. As a result, variation works occur. From the interview with Company Y's Project Manager, the construction works (especially refurbishment work) require a lot of equipment for completion, such as pad levelling, laser ruler, metal detector, good tile cutter, etc. The company must invest in the necessary equipment in order to accomplish refurbishment projects.

Table 5.17: Correlations between leftover material with VO and waste ratio

Correlations				
			VO	Waste Ratio
Spearman's rho	Leftover Material	Correlation Coefficient	-.057	.011
		Sig. (2-tailed)	.458	.887
		N	172	172

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

From Table 5.17, there was no significant value between leftover material with VO and waste ratio. From the survey, it was found that leftover material is not significant in contributing to VO or wastage of material in refurbishment projects.

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Table 5.18: Correlations between ordering errors with VO and waste ratio

Correlations				
			VO	Waste Ratio
Spearman's rho	Ordering Errors	Correlation Coefficient	-.002	-.035
		Sig. (2-tailed)	.979	.648
		N	172	172

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

According to the analysis, there was no significant value between ordering errors with VO and waste ratio.

5.4 Anova Analysis

In this section, the researcher analysed the relationship between waste minimisation variables and refurbishment projects. The method to establish the relation was by using Anova in SPSS 16.0.1. Table 5.19 summarised the Anova results between variables and refurbishment projects.

Table 5.19: Anova analysis for waste minimisation

ANOVA		
	F	Sig.
Use Prefabricated Material	.112	.953
Purchasing Management	3.959	.009
Education Training	2.489	.062
Proper Layout Planning	.472	.702
Recycle on Site	.352	.788
High Level Management	.045	.987
Recycle Facilities	2.982	.033
Metal Formwork	7.442	.000

Sig. ≤ 0.05, there is a relationship with waste minimisation in refurbishment

From Table 5.19, the highlighted factors with significant value ≤ 0.05 included “Purchasing Management”, “Recycle Facilities” and “Metal Formwork”. From this result, it can be concluded that these waste minimisation factors are highly effective and can contribute to waste minimisation in refurbishment projects.

From the analysis of the previous chapter on the project performance variable, it was found that “Metal Formwork” was the most significant. Peng & Scorpio (1997) had supported that the reduction of construction waste is one of the best solutions.

Reduction is the best and most efficient method for minimising waste and eliminating numerous waste disposal problems. The formwork made of metal can be recycled and reused again and again. Thus, waste can be decreased. Reductions in waste and environmental merits will occur if less timber formwork is used; less wet trades carried out on site will result in less water pollution; reduced construction activities will result in less generated noise nuisance; and other overall improvements will occur with effective waste management and waste disposal.

The second significant factor was “Purchase Management”. Purchase management is the management of purchasing materials for construction processes. The key for success in this management factor would be on clients, whereby, when purchasing raw materials, factors that would lead to waste generation must be considered. Tam (2007) stated that “Purchase Management” is considered as one of the most effective measures to implement waste management plan compared to other methods mentioned in the paper. By having an effective purchase management, waste can be efficiently reduced from additional, over-purchased materials.

According to Dainty & Brooke (2004), clients always request effective waste performances from the main contractors where the requirement must channel downwards (subcontractors and suppliers). Specialist contractors must be responsible in applying waste management strategies to be adopted in the project waste management plan. It is common that the more familiar this is to the industry or scope of work, the more effective the measures would be carried out on site.

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The third was “Identification of Available Recycling Facilities”. This is the method of knowledge for recycling facilities available on site. It was assessed that it was significant for the contribution to the actual cost of the project. As assumed by the researcher, this implementation was the same as “On-site Recycling Operation” which both had a negative impact on the actual cost of the project. From Chapter 2, these two variables were identified to benefit the cost of the project. Begum (2006) reported that huge amounts of household waste were from construction generated waste. Therefore, as much as 73% of waste materials can be reused and recycled for waste minimisation in a construction site. This is economically beneficial as the advantages from the reuse and recycle waste material rate are approximated at 2.5% of the total construction cost. Thus, the sector can contribute to cost saving by conducting waste minimisation practices on site. However, the results obtained from the analysis was unfavourable to the cost of the project. In the researcher’s opinion, these implementations require a high level of understanding and knowledge so as to apply in Malaysia’s construction industry.

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5.5 Reliability Analysis

Table 5.20: Reliability statistics for causes of waste generation

Reliability coefficient	Value
Alpha	0.838

Table 5.21: Reliability statistics for waste implementation

Reliability coefficient	Value
Alpha	0.800

Reliability test was conducted to ensure that the questions designed in the questionnaire are reliable and able to provide information about the relationships between the individual items on the scale. Reliability is also an assessment of the degree of consistency between multiple measurements of a variable. The objective was to ensure that responses are not too varying so that measurements taken are reliable. The most frequently used measure of reliability is internal consistency, which applies to the consistency among the variables in the summated scale.

In this study, Cronbach's coefficient alpha was used to test the reliability of the 16 and 8 variables used in the Correlation analysis. From the analysis, the values were 0.838 and 0.800, respectively. These values clearly explain that the questionnaire has a degree of reliability of 80% and above. This result also proved that the primary data obtained from the questionnaires can be relied upon and is suitable for analysis.

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5.6 Summary

From the above analysis, the critical reasons that prompt waste generation in refurbishments include lack of design information, damage during transportation, poor supervision, inappropriate construction methods and lack of coordination. Whereas, the significant factors that contribute to variation orders include lack of design information, poor site management and scarcity of equipment. On the other hand, effective waste minimisation could be achieved by improving purchase management, identification of availability of recycling facilities and using metal formwork. The barriers of waste management implementation are generally greater compared to other construction issues; prioritising the importance of waste minimisation is relatively low. However, these results provided significant factors and simplified waste management methods to the parties involved in refurbishment. The following chapter summarised all the findings and provided the recommendations for future research.

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CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter provided a summary of all the discussions found in the previous chapters of this research. This study began with recognising the research problems of construction waste in refurbishment projects, the given problems of existing waste generation variables and minimisation measures in the Klang Valley area. This research project attempted to acquire a better understanding of how waste generation variables affect the cost of refurbishment project performance in Klang Valley, and determined the effectiveness of waste minimisation.

Appropriate assistance to clients during the pre-tender stage is crucial to avoid unnecessary extra work throughout construction, which will result in more time consumption and waste. Benefits in waste minimisation activities should be highlighted to clients. Results from the above-mentioned action could attribute to the reduction of waste material in Malaysia's construction industry. Material wastage could occur in design, procurement, material handling and operation stages. From this research, the significant reasons that lead to waste generation in refurbishments are those related to conventional construction methods, poor workmanship, poor storage, wrong handling, disorderly construction sites and inadequate management techniques. The barriers of waste management implementation are generally greater compared to other construction issues, and prioritising importance towards waste minimisation is relatively low.

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6.2 Conclusion

The objectives of this research were to examine the relationship between waste of materials and cost performance; to identify variables that prompt waste in refurbishment projects, and to study the effectiveness of waste minimisation in the refurbishment industry. In order to obtain an adequate analysis that covers the cost of refurbishment projects and the effectiveness of waste minimisation, this research strove to answer 3 objectives:

Objective 1: To understand managing waste in the construction industry.

Chapter 2 explained what waste is, the side effects and disadvantages of excessive waste produced, as well as, what waste management and current waste management practices are in the construction industry. Waste management procedure should be tenacious, considering cost implicative insinuations and cost relevance, which will result in waste minimisation. Waste generation by construction activities carry high particle contamination, which is very difficult to be recycled. As a result, the materials cannot be recycled and used again. This is where an increase in cost will take place. At the end of the day, the wastes generated will go to landfills. These costs will either impact the clients or the contractors. It is recommended to liaise with major parties in every aspect of waste management due to the cost impacts, either to the clients or to the contractors.

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Objective 2: To identify factors that contribute to waste generation in refurbishment projects.

Chapter 3 described construction and refurbishment wastes, waste generation factors, effectiveness of waste minimisation practices in the construction industry and waste generation factors in refurbishment projects. Significant reasons that drive waste generation in refurbishment are mainly related to the conventional construction method, poor workmanship, poor storage, mishandling, disorderly construction sites and ineffective management techniques. The barriers of waste management implementation are generally greater compared to other construction issues; prioritising the importance of waste minimisation is relatively low.

Objective 3: To examine the relationship between waste generation and cost performance.

Chapter 5 derived a comprehensive data analysis using SPSS to provide prudent results in the relation between waste generation and cost performance.

Table 6.1: Significant correlated variables

Variables	Variation Order	Waste Ratio
Lack of Design Info	-0.163*	0.221**
Damage During Transportation	0.068	0.163*
Poor Site Management	0.164*	0.037
Poor Supervision	0.088	0.257**
Inappropriate Construction Method	0.100	-0.201**
Lack of Coordination	0.119	0.172*
Scarcity of Equipment	-0.161*	0.071

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

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Other general conclusions derived from the study as follow:

- Waste management is a critical issue in Malaysia's construction industry, the reason is that the industry is one of the biggest generators of pollution. In fact, it is a critical issue for all countries worldwide.

- The majority of respondents are from the 'Quantity Surveyor' background. Experiences in refurbishment projects mainly include less than 10 years of experience, and less than 10 refurbishment projects involved.

- From the findings, 'Poor Supervision' was the most significant to 'Variation Order' in refurbishment projects. This means that poor supervision of refurbishment projects will cause variation orders to the projects.

- This result suggested that contractors are of the opinion that there should be improvement on the quality of supervision on site, as well as, capable supervisors.

- Supervising and monitoring workers during their tasks on site is deemed to be important. Thus, it could reduce the variation order in refurbishment projects.

- The second, third and fourth significant factors to 'Variation Order' were 'Poor Site Management', 'Lack of Design Information' and 'Scarcity of Equipment', respectively.

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- The most significant factor to ‘Waste Ratio’ in refurbishment projects was ‘Lack of Design Information’.

- The second, third and fourth most significant were ‘Inappropriate Construction Method’, ‘Lack of Coordination’ and ‘Damage During Transportation’, respectively.

- From the questionnaire surveys, together with a review of waste implementation in Chapters 2 and 3, the results indicated that with proper methods of waste implementation, it is cost saving for projects.

From the research, it can be concluded that these waste generation factors are important and more effort should be given in order to reduce the waste that occurs in refurbishment projects. With the rapid growth of refurbishment projects in Malaysia, waste has become one of the barriers for development. As discussed earlier, buildings that undergo refurbishment processes are usually occupied by existing tenants, causing refurbishment processes to be more challenging and limited in working space.

6.3 Recommendations

Refurbishment waste management is critical in most developed countries due to their aging building stock and pressing needs for environment sustainability. It addresses issues that include both society and the economy. This study identified significant variation orders and waste ratios in refurbishment projects. The involved parties should try to apply new practices to reduce variation orders and waste.

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Apart from the main objectives of this research, the survey also provided effective waste minimisation methods for refurbishment projects. From the Anova analysis, "Metal Formwork", "Purchase Management" and "Recycling Facilities" are significant to waste minimisation in refurbishment projects. This study provided empirical evidence on the significant levels of contribution and the levels of practice among waste minimisation factors. The findings will assist in the formulation of appropriate policy interventions in addressing waste management problems in Malaysia, and indirectly improve the quality of refurbishment projects in the country. Waste reduction can be achieved by implementing an effective waste management plan. Details of waste management should be listed out and acknowledged by every party involved to enhance the knowledge regarding the waste minimisation process, or to better understand the reuse of materials in the design and construction stages, respectively. Even though each refurbishment project is unique, this comprehensive result can provide descriptive information, solutions and appropriate approaches to readers.

Moving forward with waste minimisation in refurbishment requires a thorough source evaluation of design waste, which should influence a change in the waste reduction design paradigm. Thus, these implementations may be helpful in saving cost for refurbishment projects, waste management planners, as well as, policy makers as they manage waste in order to reduce environmental pollution; hopefully improving performance within the industry. There may be future studies that cover respondents in Malaysia's refurbishment projects, and not just limited to contractors only.

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Appendix 1: Questionnaire Design Survey

Dear respondents,

I am a researcher from the Faculty of Built Environment, University of Malaya. I am currently conducting a sample survey for a research entitled, “Determining Waste Generation Factors in Klang Valley Refurbishment Projects”.

You are selected by your profession in this study because you are qualified based on the research population criterions; having refurbishment project experiences, the project was completed before 2014 and the contract sum was more than RM500,000.00.

The study concentrates on the major causes of material wastage which includes attitudes toward waste minimisation amongst labourers and contractors, material selection in tenders, design changes during construction, waste management and reuse of materials, reuse facilitation or recycling for sorting different types of waste, etc. Therefore, it is important to raise awareness for waste minimisation in order to improve construction cost and fully utilise the materials in construction.

I would like to seek your cooperation to participate in this questionnaire study. The survey will not take more than 15 minutes of your time. I hope you will participate in this survey.

Thank You very much for your kind cooperation!

Sincerely,

CHAI KOK LIONG

Master of Science (Building)

Faculty of Built Environment

University Malaya (UM)

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UNIVERSITY OF MALAYA
KUALA LUMPUR

FINAL SURVEY ON THE MANAGING WASTE IN REFURBISHMENT PROJECTS

Return Address:
CHAI KOK LIONG
Fakulti Alam Bina
University Malaya
50603 Kuala Lumpur

Reference No. :
Telephone : 012-3716837
Email :alexchai86@hotmail.com

NOTE ABOUT THE QUESTIONNAIRE:

Please answer all questions. If you are unable to answer the questions because of you consider them irrelevant or unclear, please put question mark next to them.
Return the completed questionnaire in the envelope provided.
Your identity and that of your firm will remain strictly confidential to us.

Objective of the survey
The main objective of this questionnaire is to identify the causes of waste generation in refurbishment projects and effectiveness of waste implementation based of its performance which is the total cost of the project.

Definitions
Refurbishment refers to upgrade, major repairs work, renovations, rehabilitation, alterations, conversions, extensions and modernization of **existing building**, but exclude routine maintenance and cleaning work.

Waste any losses produced by activities that generate direct or indirect costs but do not add any value to the product

Causes of waste generation are referring to factors or variables that contribute to waste generated in refurbishment projects.

Waste implementation is referring to techniques or factors of waste minimization in refurbishment projects.

Performance of project is measure in term of cost variance of product.

Eg. : Frequent design changes may contribute to waste generations. 1 2 3 4 5
Strongly disagree O O O O O Strongly agree

Legends: 1=strongly disagree 2= disagree 3=neutral 4= agree 5=strongly agree

Before you answer the following questions, please select a project that satisfied the following criteria:-

- The project was completed before years 2014
- The contract value of the project more than RM 500,000 (Five hundred thousand Ringgit)

Your answer must be based on a selected refurbishment project

1. YOUR PARTICULARS

1.1 What is your position?

[ ] Project Director [ ] Project Manager [ ] Project Engineer [ ] Quantity Surveyor [ ] Others, please specify ___________

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1.2 How long have you been involved in the construction industry?

[ ] less than 5 years [ ] 5 to 10 years [ ] 10 to 15 years [ ] more than 15 years

1.3 How many refurbishment projects have you been involved?

[ ] less than 5 projects [ ] 5-10 projects [ ] 10-15 projects [ ] more than 15 projects

2. PROJECT CHARACTERISTICS

2.1 Please indicate the type of refurbishment project selected.

[ ] Residential	[ ] Office	[ ] Factory	[ ] Education institution
[ ] Hospital	[ ] Hotel	[ ] Shop	[ ] other, please specify __

2.2 The original contract value of the refurbishment project: RM ___________________

2.3 The final contract value of the refurbishment project: RM ___________________

2.4 The duration for the construction stage: _______________ weeks

3. CAUSES OF WASTE GENERATION

3.1 Please note the following causes of waste generation for the selected refurbishment project.

i.	Frequent design changes	Strongly disagree O O O O O Strongly agree
ii.	Design errors	Strongly disagree O O O O O Strongly agree
iii.	Lack of design information	Strongly disagree O O O O O Strongly agree
iv.	Wrong material storage	Strongly disagree O O O O O Strongly agree
v.	Poor material handling	Strongly disagree O O O O O Strongly agree
vi.	Damage during transportation	Strongly disagree O O O O O Strongly agree
vii.	Poor quality of materials	Strongly disagree O O O O O Strongly agree
viii.	Equipment failure	Strongly disagree O O O O O Strongly agree
ix.	Poor site management	Strongly disagree O O O O O Strongly agree
x.	Poor controlling	Strongly disagree O O O O O Strongly agree
xi.	Poor supervision	Strongly disagree O O O O O Strongly agree
xii.	Inappropriate construction method	Strongly disagree O O O O O Strongly agree
xiii.	Lack of coordination among parties	Strongly disagree O O O O O Strongly agree
xiv.	Scarcity of Equipment	Strongly disagree O O O O O Strongly agree
xv.	Leftover materials on site	Strongly disagree O O O O O Strongly agree
xvi.	Ordering errors	Strongly disagree O O O O O Strongly agree

4. WASTE IMPLEMENTATIONS

4.1 Please note the following waste implementations for the selected refurbishment project.

i.	Use of prefabricated building components.	least important O O O O O very important

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ii. Purchase management least important O O O O O very important

iii. Education and training least important O O O O O very important

iv. Proper site layout planning least important O O O O O very important

v. On-site waste recycling operation least important O O O O O very important

vi. High level management commitment least important O O O O O very important

vii. Identification of available recycling facilitate

least important O O O O O very important

viii. Use of metal formwork least important O O O O O very important

5. <u>PERFORMANCE OF THE PROJECT</u>

5.1 What is the percentage of 'variation order' of the total contract value due to waste generation? [ ] 0-10% [ ] 11-20% [ ] 21-30% [ ] More than 30%

5.2 What is the ratio of **actual waste cost** incurred to **estimated waste cost** in the refurbishment project.

Eg. If the actual waste cost incurred was RM 10,000.00 and the estimated waste cost was RM 8,000.00, divided RM 10,000.00 by RM 8,000.00; so the ratio is 1.25

[ ] 0 to 0.8 [ ] 0.81 to 0.9 [ ] 0.91 to 1.00 [ ] 1.01 to 1.1 [ ]1.11 to 1.20 [ ] more than 1.20

If you have any comment concerning the questionnaire or the research topic, please write on the space at the back of this page.

THANK YOU VERY MUCH FOR TAKING PART IN THIS SURVEY

If you would like the summary of the previous preliminary and this final research result, free of charge, please enter your name and email address below.

Name: E-mail