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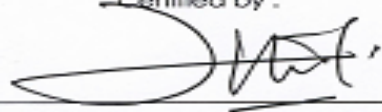
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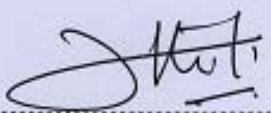
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CONSTRUCTION WASTE GENERATED IN CONVENTIONAL METHOD OF  
HOUSING CONSTRUCTION

ONG ENG GUAN

A project report submitted in partial fulfillment of the  
requirement for the award of the degree of  
Master of Science (Construction Management)

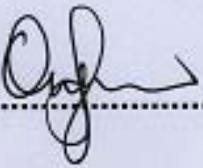
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Specially dedicated to my beloved wife, Chai Lee Chan, my dearest daughter,  
Joanne Ong Joo Yen and my cheering son, Ong Wei Qiao  
For everlasting love and care.....

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## ABSTRACT

Construction waste which is produced or generated during construction of structures consists of timber, wire, broken brick, glass, pipes, concrete, metal and plastics (if the metal or plastics are a part of the materials of construction or empty containers for such materials for paints), coatings, and solvents, asbestos, any liquid, compressed gases or semi-liquids. The type of material waste are also include drywall, masonry, roofing; structural metal, wire, insulation, Styrofoam, other packaging materials and building material such as sand, rocks, and dirt. Garbage however is not construction waste and the disposal of such materials must be in accordance with the regulations of the Municipal Authority. In no event shall construction waste include dangerous or extremely hazardous waste or any kind of garbage, sewerage waste, animal carcasses, or asbestos. It is important to identify the types and quantities of construction waste in a project in order to plan a good construction waste management system on which, the disposal will be minimize with reduce, reuse and recycle are implemented. The study found that in the conventional method of construction, the total construction waste generated in a luxury landed building construction will be around 2.75kg/sqft of as built area. If reuse and recycle are being practice, the dispose waste can be reduced by 40% to 50% of the generated waste. In this study, it also concluded that the extras cost need to be provided in the material wastages at around 8% of the actual calculated material cost. It can be generally conclude that approximately RM0.25/sqf is needed for the disposal cost of the waste for the construction of high-end housing project by using conventional method.

## ABSTRAK

Bahan-bahan buangan pembinaan merupakan sisa-sisa pepejal yang terjana semasa kerja-kerja pembinaan. Bahan-bahan buangan ini adalah terdiri daripada kayu, gentian atap, jubin, dawai, batu-bata, kaca, paip, konkrit, besi, plastik dan lain-lain. Bertambahnya kesedaran orang ramai terhadap impak bahan-bahan buangan pembinaan terhadap persekitaran dan kos pembuangannya telah menjadikan pengurusan bahan buangan pembinaan sebagai salah satu aspek penting dalam pengurusan projek.. Objektif kajian ini adalah untuk mengenal pasti jenis bahan buangan yang terjana dari kerja-kerja pembinaan, mengenalpasti masalah-masalah yang dihadapi dalam pengurusan bahan buangan dan mencadangkan atau memperbaiki amalan pengurusan bahan buangan pada masa ini. Adalah mustahak untuk mengetahui jenis-jenis dan kuantiti sisa pepejal yang akan dijanakan di suatu projek supaya satu sistem pengurusan bahan buangan boleh dirancang. Kuantiti bahan buangan ini boleh di kurangkan jika kegunaan dan kitar semula dipraktikkan. Dalam kajian yang dijalankan, didapati kuantiti bahan-bahan buangan pembinaan yang dijanakan adalah 2.75kg/kakipersegi luas binaan. Dengan proses kegunaan dan kitar semula dipraktikkan jumlah ini telah dikurangkan sebanyak 40% hingga 50% daripada keseluruhan bahan buangan yang dijanakan. Dalam kajian ini juga disimpulkan bahawa kos tambahan yang diperlukan untuk pembelian bahan binaan adalah 8% daripada jumlah kos bahan binaan yang diperlukan. Kos untuk pembuangan bahan-bahan buangan pembinaan rumah kos mewah ini juga dirumuskan sebanyak RM0.25/kaki persegi luas binaan.

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## **CHAPTER I**

### **INTRODUCTION**

#### **1.1 Overview**

The construction industry in Malaysia falls into four broad sectors such as office, retail, residential and infrastructure development. The Malaysian construction sector has recovered and is going through a phase of stabilization following a period of regional recession. The construction sector grew 4.6% in 2007 compared with 0.5% in 2006. It contracted by 1.6% in 2005 and 1.9% in 2004 (The Star, Friday July 4, 2008).

According to the mid-term review report of the Ninth Malaysia Plan (9MP: 2006 – 2010), the construction sector is expected to grow at 5.8% per annum, underpinned by activities within the civil engineering, residential and commercial property sub-sectors. The Ninth Malaysian Plan focuses on infrastructure development of the country, and the government has outlined plans to spend RM220billion on development over the next five years. The government's also plans to construct 43,800 units of low-cost housing and 29,000 units of low and medium cost housing, along with housing quarters for teachers and expected to act as a catalyst for construction industry growth in the Ninth Malaysian Plan. Major infrastructure projects in Malaysia include the Ipoh - Padang

Besar electrified double-track rail project, the bullet train project between Kuala Lumpur and Singapore, Bakun hydroelectric dam project and the West Coast Expressway project. All this does not include the contribution by the private sectors on the booming of construction industry in Malaysia.

## **1.2 Problem Statement**

The Construction industry is the key indicator and driver of economic activity and wealth creation. Although this industry accounts less than 5% of the country gross domestic product (GDP), the Malaysian government is extremely protective of the industry and is taking initiative to improve the industry (The Star, Friday July 4, 2008).

The construction of residential buildings remains active and new housing schemes continue to be developed. The construction of low and medium-cost houses continues to be supported through the Malaysian Government's housing program. Luxurious and high-end landed residential properties, such as semi-detached and bungalows are still in demand, however, on a selective basis depending on its price, location and accessibility.

With the increase of properties, the needs of building material are also increase in ratio which the material cost is around 60% to 75% of the total construction cost of each trade. As a result the construction waste will also increase significantly especially those projects that are using conventional method of construction. This construction waste consists mainly but not limited to timbers, concrete's, metals, bricks, drywall or dry board, roof tiles, tiles, marble, material packaging, plastics, papers, cardboard, glazing and etc. Construction waste is becoming a serious problem in Malaysia. The

construction industry generates lots of construction waste, which caused significant impacts not only on the environment but also aroused growing public concern. Thus, the needs and the importance to know the types and quantities of construction waste that will be generate in a project.

### **1.3 Research Objectives**

The aim of this study is to investigate the construction waste generated in a housing project using the conventional method of construction. In order to achieve the aim of the study, several objectives has been established as follows:

- a) To identify the types of site construction waste generated in conventional method of luxury housing construction.
- b) To determine quantity of site construction wastes generated compared to the total built-up area of building.
- c) To investigate the construction waste management system and construction waste disposal option that practices on site.
- d) To obtain the material wastages cost and construction waste disposal cost.

### **1.4 Scope Of Study**

The scope of study can be outlined as follow:

- a) To collect data on the construction waste generated in the construction of

6 units double storey semi-detached houses, approximately 3,000ft<sup>2</sup> in build-up area for each unit.

The project for the double storey semi-detached houses in this case study is the construction and completion of 48 units of double storey semi-detached houses situated at Damansara Idaman, Petaling Jaya, Selangor Darul Ehsan

- b) To collect data on the construction waste generated in the construction of 12 units double storeys terrace houses, approximately 2,173ft<sup>2</sup> in build-up area for each unit.

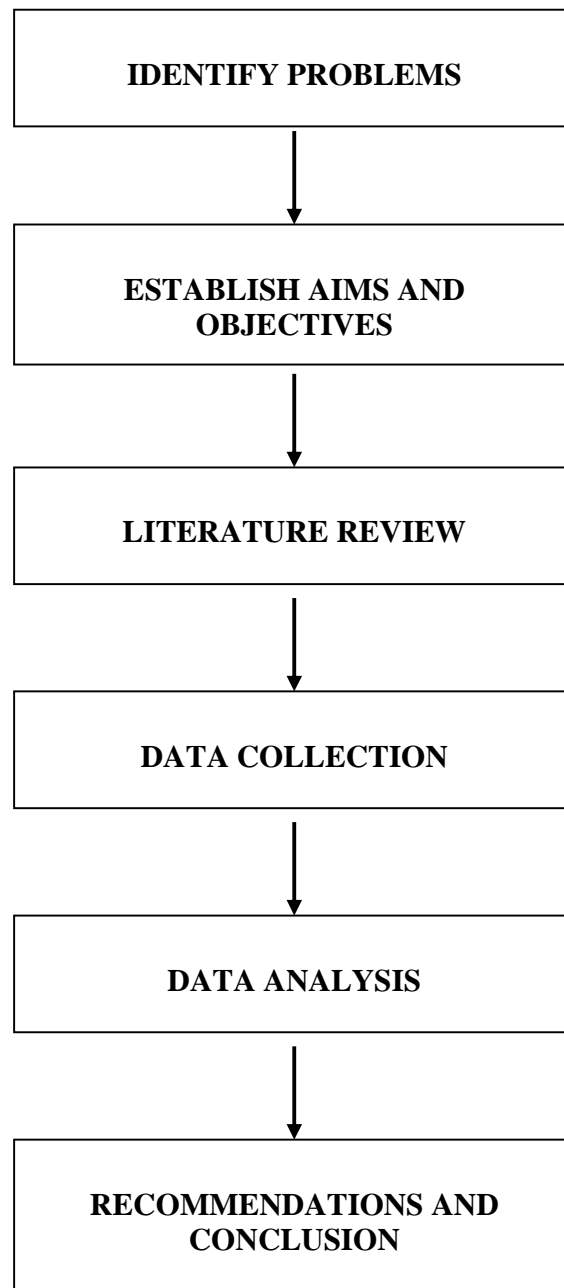
The project for the double storey terrace houses in this case study is the construction and completion of 179 units of double storey terrace houses situated at 7th mile Jalan Gombak, Selangor Darul Ehsan.

## **1.5 Research Methodology**

The study was focused on the construction waste generated in the construction of luxury residential building using conventional method of construction. The scope of study are only emphasised on the double storeys semi-detached and double storeys terrace houses. Literature review process is important and are essential in helping to establish the aims and objectives of this study. The sources of these literature reviews was obtained from reports and publications.

Data on the construction waste are then obtain from the indentified site by observing, segretions and measurement. Quantities of construction material are also obtain from the contract document and ordered quantity. All the data obtain will then be analysed before a recomendation and conclusion will be discuss. The method and detail

on this data collection, location, and analysis will be explain in more detail in chapter 3 and 4 respectively. The reseach methodology flowchart is shown in Figure 1.1



**Figure 1.1 Research Methodology Flowchart**

## **CHAPTER II**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

Construction is a unique industry. The success or failure of a project relies on the accuracy estimation done throughout the course of the project. In this chapter the types of material normally used in the construction industry will be reviewed, follow by the discussion on waste generated during the construction process at site. The waste management planning, the needs on recycle to reduce waste, the disposal option and the construction material cost will also be reviewed.

## **2.2 Construction Material**

Construction material means whatever article, material, or supply brought into the construction site by the Subcontractor or a lower-tier subcontractor for incorporation into the building or work in a project. The term also includes an item brought to the site pre-assembled from articles, materials, or supplies such as aggregate, metal, woods, cardboard, drywall, bricks and others. (Federation International du Recyclage, 2003)

### **2.2.1 Aggregate**

The word 'aggregate' is defined in Chamber's Dictionary as any material mixed with cement to form concrete. Any material can mean lead pellets for very heavy concrete with radiation shielding properties or man made lightweight aggregate to reduce the dead weight. The most common used types of aggregate, which are natural stones, rocks, sands and etc. BS 882 'Specification for coarse and fine aggregate from natural sources', as the title indicates defined aggregate by two main size grouping. Mainly material smaller than 5mm are classed as fine aggregate, while larger than 5mm are classed as coarse aggregate. Figure 2.1 shows the types of aggregate.

The sizes of aggregate specified in BS 882 go up to 40mm but the maximum sizes that can be used are governed by restriction such as the spacing between reinforcing bars and minimum concrete cover to reinforcement. Subject to others restraints selection of the largest maximum size will result the highest possible workability for a particular mix. Figure 2.2 shows that granite are commonly used as coarse aggregate in Malaysia



**Figure 2.1: Types of Aggregate**



**Figure 2.2: Granite are commonly used as coarse aggregate in Malaysia**

Fine aggregate is natural or manufactured sand consisting of hard, durable, uncoated inert particles, reasonably free from clay, silt, vegetation, or other substances determined to be deleterious. Substances which are present in amounts to cause inconsistent performance in the properties of the plastic or hardened concrete are considered deleterious. These substances such as gypsum, iron sulfide, amorphous silica, and hydrated iron oxide are considered deleterious.

The grading of an aggregate refers not only to the quality of the raw material, but to the relative proportion of different sizes of stone or grains within a quantity of aggregate. Grading limitation for coarse and fine aggregate is specified in BS 882 and 1201. BS 812 classifies various particle shapes and surface texture of aggregate from glassy to honeycombed. Mainly two shapes being considered. A rounded aggregate has less physical resistance to movement than an angular aggregate. Therefore it provides greater workability. In addition a sphere has a smaller surface area than a cube of identical weight and volume. This gives rounded aggregate the advantage of having reduced frictional surfaces. A rough textured aggregate will give a lower workability than a smooth material because of its increased surface area and also by the added mechanical resistance caused by its roughness. A rounded stone will also stick to a paste much easier than an irregular or angular stone. Therefore the more rounded, the aggregate, the greater will be the cohesion. Fine aggregate divided into two categories: natural sand and manufactured sand. Natural sand is fine aggregate resulting from glacial or waters action. Fine aggregate produced simultaneously with gravel coarse aggregate may contain crushed particles. Manufactured sand is fine aggregate from controlled mechanical breakdown of rock or air-cooled blast furnace slag or steel slag into sound, approximately cubical particles. Manufactured sand will be acceptable only when it is the primary product of the crushing operation and sized by a sand classifier. Fine aggregate manufactured from limestone may not be used in concrete wearing surfaces. Fine aggregate manufactured from steel slag may not be used in cement concrete or mortar mixture. Only fine aggregate reasonably uniform in the physical properties specified in Table 2.1 will be acceptable.

**Table 2.1: Fine Aggregate Grading and Quality Requirement (Source: BS 882)**

<b>(Mass Material Percent, Passing)</b> <b>Sieve</b>	<b>Cement Concrete Sand</b> <b>Type A</b>
3/8"	100
No. 4	95-100
No. 8	70-100
No. 16	45-80
No. 30	30-65
No. 50	10-30
No. 100	2-10
No. 200	-
Material Finer Than No. 200 Sieve Max. Percent Passing	3
Strength Ratio Min. Percent	95
Soundness Test Max. Loss Percent	10
Fineness Modulus	2.30 to 3.15

### 2.2.2 Formwork

Formwork is the term given to either temporary or permanent moulds into which concrete or similar materials are poured to form a structure. The function of this formwork is to form out the shape of the structure and the mould to receive the concrete.

The concrete is poured into this mould and when it is hardened, it will become a structure that will shape accordingly to the formwork. The formwork will be either stripped off or permanently remain as structure itself. There are a few types of formwork, mainly:

- Traditional timber formwork. This formwork is fabricated manually at site using timber and plywood. It is easy to produce but time consuming for assembly in large structures. This type of formwork will be stripped off and reused after the concrete has hardened. It has a limited lifespan. Normally 4 to 8 cycles of usage in a project.

- Engineered system formwork. This formwork is made out of prefabricated modules with a steel frame and together with a steel sheet or timber plywood for the surface. This surface is the contact area between the concrete and formwork. The advantages of system formwork, compared to the traditional timber formwork, are on the speed of construction due to easier installation, lower life-cycle costs and the durability.

- Stay-In-Place system formwork. This formwork is assembled on site, usually made of prefabricated Insulating Concrete Forms. The formwork stays in place after the concrete has hardened to provide thermal and acoustic insulation, space to run utilities, and backing for finishes.

- Stay-In-Place structural system formwork. This type of formwork is similar to the above stated, stay-in-place system formwork but with an additional function as a structural member itself after combined with the concrete. This formwork is assembled on site, usually made of prefabricated fibre-reinforced plastic forms. These formworks are in the shape of hollow tubes, and are usually used for columns and piers. The formwork stays in place after the concrete has hardened and acts as axial and shear reinforcement, as well

as serving to confine the concrete and prevent against environmental effects, such as corrosion and freeze-thaw cycles.

For the first two types of formworks, once the concrete has been poured into formwork and has hardened, the formwork will be strip-off (removed) to expose the finished concrete. The removal time of the forms is depending on the strength needed by the hardened concrete. Precaution or steps have to be considered before stripping of formwork. Spectacular accidents have occurred when the forms have been either removed too soon or under-designed to carry the load imposed by the weight of the uncured concrete. Figure 2.3 shows timber used as wall form system formwork.

(Wikipedia Encyclopedia, 2009)



**Figure 2.3: Timber Formwork**

### **2.2.3 Wood**

Wood is a product of trees, and sometimes other fibrous plants, used for construction purposes when cut or pressed into lumber and timber, such as boards, planks and similar materials. It is a generic building material and is used in building just about any type of structure in most climates. Wood can be very flexible under loads, keeping strength while bending, and is incredibly strong when compressed vertically.

There are many differing qualities to the different types of wood, even among same tree species. This means specific species are better for various uses than others. And growing conditions are important for deciding quality.

Historically, wood for building large structures was used in its unprocessed form as logs. The trees were just cut to the needed length, sometimes stripped of bark, and then notched or lashed in to place. In earlier times, and in some parts of the world, many country homes or communities had a personal wood lot from which the family or community would grow and harvest trees to build with. These lots would be tended to like a garden. With the invention of mechanizing saws came the mass production of dimensional lumber. This made buildings quicker to put up and more uniform. Thus the modern western style home was made.

Wood is one of the most versatile and frequent used products by human. Wood and the by-products are found in every area of modern existence, from the timber used in construction, furniture and domestic uses to fibre board, chipboard, paper, newsprint and cardboard. As usage for construction material, wood is strong, light, durable, flexible and easily worked. It has excellent insulating properties. In contrast to the substitutes for wood used in structural and architectural such as brick, concrete, metals and plastics, wood can be produced and transported with little energy consumed and the products are renewable and usually biodegradable (Koch, 1991).

Wood will continue to be a major construction material in subsequent decades in Southeast Asia. A large part of the volume used for construction will be in the form of lumber and plywood but more reconstituted wood-panel products will be used in the form of fibre-boards, particle board and wood-cement boards. The decreasing wood supply from natural forests will be supplemented by wood from plantations and

secondary or lesser-used species will be adopted more as construction materials. In future non-traditional materials will also be used extensively. Rubber wood looms as an important source for both household furniture and construction. The palm stem of coconut will be used in a large extent for house construction, particularly for low-cost housing. Laminated products will also become important as the supply of large-diameter wood declines further. A more extensive use of nontraditional materials will depend largely on advancing technologies in processing to promote productivity and economy. Likewise, supplementary technologies such as the production of high-quality adhesives and finishing materials from materials indigenous to the region will improve the quality of the wood construction products themselves.

The growing populations resulted in the rising of housing needs. With the demands and to meet the domestic needs, countries of the Southeast Asia are decreasing amounts of their forest resources. At the same time, a diminishing natural forest resource is creating a need to find new sources and new processes for wood-based construction materials. The present and future use of wood for construction in several ASEAN (Association of Southeast Asian Nations) countries had suggested that the future requirements must be met from some unconventional sources and with increased use of new technologies.

Although indigenous construction materials such as cement, aggregate, bricks and stones are found plenty in the various Southeast Asian countries, significant amounts of iron and steel bars are still imported by most of them. Wood remains the most important construction material that is available in the region in substantial quantities. In the coming year's wood will still continue to be a major construction material, but in a variety of new forms. Number of unconventional sources will be invented due to the declining supply of traditional tropical species. These will also be supplemented through the increased use of plantation trees and lesser-known natural species, supported by technological advances in wood processing.

The total forest resources of the region are Indonesia, Malaysia, Philippines and Thailand, has a reported area of 168.56 million hectares. This represents about 7.33 percent of the total world forests and about 14.11 percent of all tropical forests (CTFT, 1983). In addition to these natural forests there are about 3.169 million ha of man-made forests. The latest data on log production in the ASEAN countries total 42.5 million m<sup>3</sup>. By comparison, the totals log production in the ASEAN region in 1980 was 58.5 million m<sup>3</sup> or about 45 percent of the total tropical timber production. The reason for the reduction in log production in these countries is the initiative to conserve their remaining forests. As a result, most of the country bans the exports of log. The current level of log production is expected to be maintained for some time, with a strong possibility of further reduction. Figure 2.4 shows the timber logs and Figure 2.5 shows wood after process from the logs.



**Figure 2.4: Timber logs**



**Figure 2.5: Wood after process from timber log**

### **2.2.3.1 Production, developments and consumption of wood in ASEAN countries**

The number of wood-processing plants/mills can be found in the various ASEAN countries. The five countries have a total of 3, 551 sawmills with capacities of more than 500 m<sup>3</sup> each per year. The particleboard plant capacities in the region total 327,000 m<sup>3</sup>. Total fibreboard mill capacity amounts to 127,000 m<sup>3</sup>. The wood-based industries in Southeast Asia are basically export oriented although part of their outputs are channeled to local markets to meet the local demands for construction and other usage. In 1983, the local usage in Indonesia are about 4.1 million m<sup>3</sup> of lumber or 77 percent of its lumber output while Malaysia and the Philippines utilized about 55 percent of their lumber production of 3.4 million m<sup>3</sup> and 0.66 million m<sup>3</sup> respectively. Thailand's lumber output of 0.9 million m<sup>3</sup> had to be supplemented with about 0.4 million m<sup>3</sup> of imported lumber to meet their local requirements (CTFT, 1983).

In plywood utilization, Malaysia reduced its plywood export from 78 to 75 percent in 1981 for the local usage in housing/construction industry. The Philippines likewise showed increased local consumption of plywood in 1980 over the previous year, utilizing 204,000 m<sup>3</sup>. This dropped in 1981 and the local market remained depressed in succeeding years. This was due to the recession (FAO/UNDP, 1983). Likewise, Thailand noted a general decrease in plywood consumption as a result of subdued construction activity, no doubt brought about by the recession. The other panel products such as particle boards and wood cement boards are mainly for local consumption with very little foreign trade.

The forests of Southeast Asia are basically rain forests and similar species are found in the various countries in the region. The types and nature of the raw materials differs from each forest. In the past, when forest resources were still abundant, only large-diameter trees were usually utilized. Harvesting was also confined to a few commercial species. With the resources declining rapidly, smaller trees and a wider number of species are being utilized. Furthermore, more attention is being given to higher productivity so that fully utilization of trees is being attempted. This has led to the development of diversified wood products for construction. Lesser-known or small-diameter species, a common feature in the tropical rain forests is also fully utilized. In Indonesia, there are about 4,000 species, while 2,500 timber species are reported in Peninsular Malaysia and 3,800 species in the Philippines. It is estimated that Thailand's forests hold similarly large numbers of timber species. However, only a small percentage of these have been commercially important. In Indonesia only 400 tree species have been utilized in various ways and out of these only 120 are known in domestic and foreign trade (Martawijaya and Kartasujana, 1981). Likewise, in Malaysia there are only 400 species, and in Philippines about 200 species that have any commercial value. The Royal Forest Department of Thailand reported a production volume of 128 species, which means those are the commercially important species in Thailand (Thailand, 1983).

### 2.2.3.2 Type of Wood in Construction

**Cement-bonded boards.** This type of wood came in various forms and sizes such as chips, particles or narrow long strips like wood wool that has been bonded with cement to produce panel products for construction. Research on this type of panel was carried out more than 20 years ago in Europe but only now it is being seriously considered in the ASEAN countries. Malaysia, Indonesia and Thailand have in fact started into commercial production of this material. Malaysia produces wood wool cement boards and particle boards bonded with cement. Cement-bonded boards can be used for external walling. It has sound and heat insulating properties and is resistant to the attack of insects and fungi. It has great potential for low-cost housing because of its cost competitive with other materials (Anon., 1984). Wood cement board is light with a density of only  $600 \text{ kg/m}^3$ . The thermal conductivity of cement-bonded boards is lower than resin-bonded particleboard's and is comparable to fibre insulating boards.

**Glued laminated wood.** The usage of glued laminated timber as a structural component is limited primarily to beams and arches in Southeast Asia. In the late 1950s and early 1960s a private construction firm in the Philippines was producing laminated beams but the use of this material had little success. Recently, however, there has been renewed interest in wood-laminated structural components and wood lamination in Malaysia. As sources of wood construction materials diversified from large-diameter and high quality logs in natural forests to small-diameter and lower-quality logs in plantation forests, the wood-lamination process permits the latter to be converted into high quality construction components. Previously the cost of laminated timber was prohibitive and it was therefore unpopular. However, with the increasing cost of conventional timber, laminated materials have become more competitive. A variation of laminated timber is laminated veneer lumber (LVL). It consists of veneers laminated in such a way that the veneer grains lay in the same direction. LVL was used in the 1960s in Japan for furniture and pianos (Sasaki, 1981). LVL manufacture permits low-grade

logs and those from thinning to be used. Although these types of logs have severe knots their influence on strength may not be important if the ply number is large enough and the knots are distributed at random (Sasaki, 1981). The production of LVL can be an extra product in plywood manufacturing. At least two plywood plants in the Philippines are already producing LVL classified as uni-ply but only export to Japan. Further studies must be conducted on various small-diameter and plantation species to develop processing techniques and the effect of butt joints, glue-line, and veneer thickness on mechanical properties. Production costs also need to be reduced in order to exploit LVL into competitive levels.

**Palmwood for construction.** Palmwood is one of the newer construction materials. The lumber from the coconut stem (*Cocos nucifera*) has been most studied and used. Although palmwood does not come from the traditional stem, the large quantities of it in Asia, Africa and Latin America make it a highly potential material for construction. The coconut is grown as an agricultural crop in Indonesia, Malaysia, Philippines and in Thailand. Coconut trees become unproductive after 50 years when they are replaced. In the Philippines, it is estimated that the total land area planted with coconut is about 3.16 million ha with approximately 411 million coconut trees. The Philippines alone has close to 84 million mature coconut palms. India, Indonesia, Malaysia, Sri Lanka and Thailand have an average of about 96.6 million mature palms (Mosteiro, 1985). At an estimated 0.28 m<sup>3</sup> of lumber yield per stem. The total estimated volume of lumber from coconut in Asia, including that of the Philippines, would be about 50.6million m<sup>3</sup>. This volume could supplement conventional wood for construction. The importance of coconut lumber in Asia and the Pacific was emphasized in the workshops held in the Kingdom of Tonga in 1976 (Anon., 1976) and in the Philippines in 1979. Since then, several training projects and programmers have been undertaken and sponsored by FAO and UNDO in Asian countries on the properties and processing of coconut. Monographs on coconut-wood processing and use have also been published (FAO, 1985). The coco-stem has been used for secondary transmission poles, bridges and posts. However, it has a very low durability and deteriorates within three

years when in contact with the soil. Treatment with preservative is essential when it was usage for outdoors or in contact with the ground, In the Philippines coco-timber is now found in local lumber outlets. At present, coco-lumber is about 40 percent cheaper than conventional lumber. With better understanding of its properties and better handling of the application, the usage in construction is expected to increase appreciably. Oil-palm also been planted extensively in Southeast Asia, especially in Malaysia, where it is estimated to be about 1,000,000 ha of oil-palm plantations. The Philippines has a very limited area for oil-palm plantation. Malaysia is apparently studying the basic and technological properties of palm oil for future utilization.

#### **2.2.4 Cardboard**

Corrugated cardboard was patented in England in 1856. Corrugated cardboard is made of paper and consists of a fluted piece of paper between two flat liner boards. This construction results in a thicker, more durable product that is widely used for shipping. Corrugated cardboard is also called pleated paper and was originally used as a liner for hat boxes, designed to protect tall hats. A patent for corrugated cardboard for use in shipping was issued 20 December 1871 to Albert Jones of New York City. Corrugated cardboard was used for protecting bottles and glass lantern chimneys when shipping. Oliver Long made a significant design change and added liner sheets to both sides, creating the corrugated cardboard design still in use today. A machine to manufacture corrugated cardboard was built in 1874 by G. Smyth. The combination of these two changes significantly increased the demand and use of this new product. Corrugated cardboard became a very important product when Robert Gair used it to form the corrugated box in 1890. This box was able to replace wooden crates and boxes at a lower price, without losing the ability to protect the product during shipping. The corrugated cardboard box allowed products to be shipped without damage, greatly increasing the size of the export market. Corrugated cardboard is the most common

building product packaging material. Quantities are increasing as more and more building components are delivered to jobsites as finished products. Although cardboard may not contribute much on the total weight, it can represent as much as 30 percent of the total volume and, unconsolidated, can send your jobsite dumpster to the landfill long before it is necessary. You can handle this material yourself by engaging a nonprofit organization or if any local hauler is interested. Cardboard is a generic non-specific term for a heavy-duty paper based product. Cardboard or known as corrugated paper in the industry is a heavy wood-based type of paper, notable for its stiffness and durability. It was first invented in China some time in the 15th century, and is used for a wide variety of purposes. One of its more common uses is as a packaging material (Farlex, 2001). Corrugated fiberboard is a paper-based construction material consisting of a fluted corrugated sheet and one or two flat linerboards. It is widely used in the manufacture of corrugated boxes and shipping containers. The corrugated medium and linerboard are made of paperboard, a paper-like material usually over ten mils (0.010 inch, or 0.25 mm) thick. Cardboard might be any heavy paper-pulp based board. Figure 2.6 shows a sample of cardboard. (Wikipedia Encyclopedia)



**Figure 2.6: Cardboard (Source: Wikipedia)**

### 2.2.5 Drywall

Drywall waste makes up about 15 percent of jobsite waste, which is the equivalent of one pound per square foot of living space. Clean waste gypsum board, after being ground, can be recycled into new drywall, used for some types of animal bedding, or applied as a soil amendment. Drywall manufacturing plants across the country are gradually gaining the technology for recycling construction site waste, but few plants can currently take significant quantities. Research has been recently undertaken to determine the suitability of various agricultural uses of waste gypsum board. It can be cost-effective to cut and stack waste drywall into uninsulated wall cavities. Care must be taken to place pieces securely to prevent rattling, to choose framing cavities without wiring runs, and to use cavities in closets, basements, and garages in which interference with subsequent additions or renovations is less likely. This approach addresses any concerns of the homebuyer or other trades.

Drywall also known as wallboard, gypsum board, plasterboard is a building material consisting of gypsum formed into a flat sheet and sandwiched between two pieces of heavy paper. It is the most common material globally for the construction of interior walls and ceilings. Drywall is typically found in four-foot wide sheets of various lengths, commonly 8 feet, 10 feet, or 12 feet. Drywall is cut to size by scoring the paper on the front side (usually white), breaking the sheet along the cut, scoring the paper backing, and finally breaking the sheet in the opposite direction. Small features such as holes for outlets and light switches are usually cut using a keyhole saw. Drywall is then fixed to the wall.

### **2.2.6 Masonry**

Masonry is an important trade in construction especially in building. The common materials of masonry construction are bricks, stone, concrete block, grass block tile and etc. All these are laid or joint together using mortar. Masonry is a highly durable form of construction because the materials used are not much affected by the elements, but the quality of the mortar and the pattern the units are laid in can strongly affect the quality of the overall masonry construction. Masonry is commonly used for the wall.

Brick masonry is the most common type of masonry, and may be either solid or veneered. (Farlex, 2001) Brick veneer construction has strength imparted by a framework of wood or a rough masonry wall of other material over which is placed a layer of bricks for weatherproofing and providing a finished appearance. The brick veneer wall is connected to the structural walls by "brick ties" or metal strips that are attached to the structural wall and mortar joints in between of the brick veneer. Masonry is strong in compression, but is relatively weak when subject to tension or sideways loads, unless reinforced. Walls are often strengthened against sideways loads by thickening of the entire wall, or by building masonry piers at intervals. The strength of a masonry wall is not entirely dependent on the bond between the building material and the mortar. The friction between the interlocking blocks of masonry is often strong enough to provide a great deal of strength on its own. The blocks sometimes have grooves or other surface features added to enhance this interlocking, and some masonry structures forego mortar altogether. Stone masonry without the use of mortar was common in early civilizations. (Farlex, 2001)

### 2.2.7 Metal

Metal is an important construction material and widely being utilized in the construction industries. Metals have certain characteristic physical properties. They are usually shiny, have a high density, ductile and malleable. Usually have a high melting point, hard, and a good conduct to electricity and heat. However, this is mainly because of its low density, soft and lows melting point. Metals happen to be reactive and are rarely encounter them in their elemental, metallic form. Figure 2.7 shows the steel coiled wire rod and Figure 2.8 shows steel bar that are used as reinforcement in concrete.



**Figure 2.7: Steel Coiled wire rod**



**Figure 2.8: Steel Bar**

Metal is used in building steel homes, steel roofing, Clear-Span buildings and other construction works. In concrete structures, the reinforcement used are steel bars, rods, and etc. Wire is used to tie together the steel reinforcement and nails or metal screws are used on formwork assembly. Iron and steel are used widely in the construction of roads, railways, infrastructure, and buildings. Most large modern structures, such as stadiums, skyscrapers, bridges, and airports, are supported by a steel skeleton. Even those with a concrete structure will employ steel for reinforcing. In addition to widespread use in major appliances and despite growth in usage of aluminium, it is still the main material for car bodies. Steel is used in a variety of other construction-related applications, such as bolts, nails, and screws. Other common applications include shipbuilding, pipeline transport, mining, aerospace, white goods (e.g. washing machines), heavy equipment (e.g. bulldozers), office furniture, steel wool, tools, and armour in the form of personal vests or vehicle armour.

Metal framing cut-off waste typically generated from a single home can be over 200 pounds. Although it does not represent a significant portion of your disposal costs, it is the only waste other than cardboard generated by your metal subcontractor. If it is returned to a central collection area, such as a siding or building supply distributor, it can contribute to quantities large enough to warrant recycling.

### **2.3 Waste**

Definitions of 'waste' invariably refer to lack of use or value or 'useless remains' (Concise Oxford Dictionary). Waste is by-product of human activity. Physically, it contains the same materials as are found in useful products. It only differs from useful production by its lack of value. Waste can be classified by a multitude of schemes: by physical state (solid, liquid, gaseous) and then within solid waste by: original use (packaging waste, food waste, etc), by material (glass, paper, etc.), by physical properties (combustible, compostable, recyclable), by origin (domestic, commercial, agricultural, industrial, etc.) or by safety level (hazardous, non-hazardous). Household and commercial waste is often referred together as Municipal Solid Waste (MSW). Household waste is one of the hardest sources of waste to manage effectively. It consists of a diverse range of materials (glass, metal, paper, plastics, organics) totally mixed together. MSW composition is also variable, both seasonally and geographically from country to country and from urban to rural area. In contrast, commercial, industrial and other solid wastes tend to be more homogeneous, with larger quantities of each material (McDougall et al., 2001).

### **2.3.1 Construction Waste Definition**

Construction waste means solid waste which is produced or generated during construction of structures. Construction waste consists of lumber, wire, sheetrock, broken brick, shingles, glass, pipes, concrete, and metal and plastics if the metal or plastics are a part of the materials of construction or empty containers for such materials for paints, coatings, solvents, asbestos, any liquid, compressed gases or semi-liquids. Garbage is not construction waste and the disposal of such materials must be in accordance with the regulations of the Municipal Authority. The regulatory definition of construction waste includes concrete, drywall, masonry, roofing, siding, structural metal, wire, insulation, and other building material; and plastics, Styrofoam, twine, baling and strapping materials, can buckets, and other packaging materials and containers. It also includes sand, rocks, and dirt that are used in construction. In no event shall construction waste include dangerous or extremely hazardous waste or any kind of garbage, sewerage waste, animal carcasses, or asbestos.

Construction Waste shall mean all non-hazardous waste material and rubble resulting from the construction, alteration, repair, removal or demolition of buildings or from the production or development of real property which is customarily handled and transported by means of roll-off boxes, bodies or containers. (Ordinance No. 657.6 An Ordinance Of The County Of Riverside Amending Ordinance No. 657 Regulating The Collection, Transfer, And Removal Of Solid Waste) “Construction waste” means used or discarded materials removed from premises during construction or renovation of a structure resulting from construction, remodeling, repair, or demolition operations on any pavement, house, commercial building, or other structure. (Alameda County Waste Management Board: November 17, 1999). Construction waste means any substance, matter or thing which is generated as a result of construction work and abandoned whether or not it has been processed or stockpiled before being abandoned. It is a mixture of surplus materials arising from site clearance, excavation, construction,

refurbishment, renovation, demolition and road works. Over 80% of construction waste are inert and are known as public fill. Public fill includes debris, rubble, soil and concrete which is suitable for land reclamation and site formation.

As general construction waste means:

- Waste from building materials, packaging, and rubble resulting from construction, demolition, remodeling, and repair of pavements, houses, commercial buildings, and other structures, and from road building and land clearing; and
- does not include asbestos; contaminated soils or tanks resulting from remediation or cleanup at any release or spill; waste paints; solvents; sealers; adhesives; or similar hazardous or potentially hazardous materials. (Daniel H. Tuttle, 1997)

Under current law, "construction waste" means those materials resulting from the alteration, construction, destruction, rehabilitation, or repair of any manmade physical structure ("physical structure built by humans" under the bill), including, without limitation, houses, buildings, industrial or commercial facilities, or roadways. The bill expands the definition to include incidental food, beverage containers, food packaging, newspapers, magazines, and non hazardous construction material packaging that are generated and commingled by individuals who are working at the construction or demolition site where the materials were generated.

(Sub.S.B. 199, 124th General Assembly Sec. 3714.01 (C).)

A significant portion of municipality waste is construction related, so its reduction becomes important. Construction companies benefit by reducing the waste generation in a number of ways, including reducing transportation and landfill deposition costs, and the purchasing costs of virgin materials. Waste production at a construction site may result from a lack of attention being paid to the size of the products used, lack of interest of contractors, and lack of knowledge about construction

during design activities. About 1–10 percent by weight of the purchased construction materials, depending on the type of material, leaves the site as waste. Generally, 50 to 80 percent of the construction waste is reusable or recyclable (Bossink and Brouwers, 1996). In terms of sustainability, the topic of management and reduction of construction waste can be considered an issue that focuses on the danger of depletion of materials used in the construction industry, such as timber, sand, and gravel. The topic also deals with the danger of environmental contamination because it is still common practice to transport construction waste to landfills. Construction and demolition waste as percentages of all solid waste that enter landfills in various countries are outlined in Table 2.2. The importance of the construction waste management is illustrated by the data. Identification of the composition of waste is also relevant for an efficient waste management process due to the amount of waste that is reusable or recyclable. Examinations of construction waste composition in Europe and the United States have yielded data summarized in Table 2.3

**Table 2.2: Construction and Demolition Waste as Percentages of All Solid Waste that Entering Landfills. (Source: Bossink and Brouwers, 1996)**

<b>Country</b>	<b>Construction and Demolition Waste (by weight) percentage (%)</b>
United States	26
Australia	20-30
The Netherlands	20-29
Germany	19
Finland	13-15

**Table 2.3: Composition of Construction and Demolition Waste, (Source: (Hettiaratchi et al., 1997))**

Construction and Demolition (C&D) Waste Category	Composition (by weight) Percentage %			
	Spencer (1991)	Bossink and Brouwers (1996)	AEP (1995)	CH2M Hill (1992)
Asphalt	46%			
Concrete	14%	13%		70%
Metal	5%		7%	6%
Wood	26%		35%	13%
Clay Stone Tablets		29%		
Concrete and Wood Piles		17%		
Clay Bricks		14%		6%
Clay Roof Tiles		10%		
Cement Mortar		8%		
Paper/ Cardboard Packing Material		7%	8%	
Rubble, Aggregate and Ceramics including Concrete			24%	
Building Materials including Gypsum Board			17%	2%
Glass			3%	
Plastics			2%	
Other Mixed C&D Waste	9%	2%	4%	3%
<b>TOTAL</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>

The recent expansion of the construction industry in Slovenia is reflected in its waste generation, currently reaching an annual 2.3 million tonnes. This is equivalent to more than 25% of waste generation in 1995. The new definition of construction waste includes excavation wastes, concrete and brick wastes, asphalt wastes and all demolition wastes. Some 30% of these wastes arise from excavations. This material is to a large extent reusable in surface construction. Problems are linked to construction wastes from new constructions and reconstruction's, and discarded concrete, bricks and gravel from the demolition of old structures in residential areas. The high level of generation of construction waste is expected to continue till 2005. The management of construction waste is not regulated. Consequently, much of it seems to be dumped at landfill sites and may accelerate the exhaustion of capacities of municipal sites. Table 2.4 below show the estimated waste generated and Table 2.5 show the common sources of construction waste generation

**Table 2.4: Estimated waste trends, 1995-2010, (Source: Strategic Guidelines on Waste Management, 1996)**

Type of Waste	Quantities (mln tones)		
	1995	2000	2010
Municipal Waste	0.9	1.0	1.2
Construction Waste	2.3	2.3	1.7
Mining and Manufacturing Waste	0.9	0.9	0.9
Energy Waste	1.2	1.3	1.4
Agricultural, food and forestry waste (dry matter)	3.5	3.8	4.0
<b>Total</b>	<b>8.8</b>	<b>9.3</b>	<b>9.2</b>

**Table 2.5: Common sources of construction waste generation. (Source: Characterization of Construction Site Waste, 1993)**

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

### 2.3.2 Types and Quantities of Construction Waste

The amount of waste produced during home construction depends on the size of the home, the type of construction, and the techniques used by the builder and the trade contractors. However, in an average 2,000-square-foot home, it is estimated that the quantities of waste generated where roughly 80 percent of it is recyclable. Table 2.6 shows the typical construction waste generated by the construction of a 2000 square foot home.

**Table 2.6: Typical Construction Waste Estimated for a 2,000 Square Foot Home. (Source: Smart Growth Network, 2000)**

<b>MATERIAL</b>	<b>WEIGHT (in pounds)</b>	<b>Volume (in cubic yards)*</b>
Solid Sawn Wood	1,600	6
Engineered Wood	1,400	5
Drywall	2,000	5
Cardboard (OCC)	600	20
Metals	150	1
Vinyl (PVC)**	150	1
Masonry***	1,000	1
Hazardous materials	50	-
Other	1,050	11
<b>Total</b>	<b>8,000</b>	<b>50</b>

\*Volumes are highly variable due to compressibility and captured air space in waste materials.

\*\*Assuming three sides of exterior clad in vinyl siding.

\*\*\*Assuming a brick veneer on home's front facade.

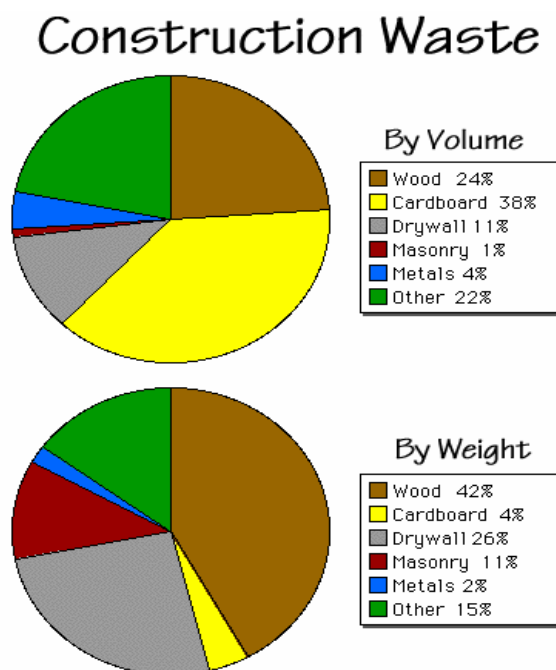
Source from the National Association of Home Builders (NAHB) Research Center, Washington reported on average, a single-family house contains 13,127 feet of lumber boards, 14 tons of concrete, 2,085 square feet of flooring material, and 2,427 square feet of roofing material. Reducing material waste can increase profits for a builder by reducing tipping fees, reducing labor costs associated with hauling waste (estimated to be 2.4 hours per ton), and by reducing the amount of raw materials that need to be purchased.

From the source of Characterization of Construction Site Waste (1993), Metro Solid Waste Department Portland, the amount of Waste from Construction after several studies have been conducted on the amount of recyclable waste generated on commercial and multi-family residential construction projects. Construction of a 5,000-square foot restaurant generated 12,344 pounds of waste, or 2.46 pounds per square foot. This waste included the following recyclable materials of wood 7,440 pounds, cardboard 1,414 pounds and gypsum wallboard 500 pounds. Construction of a 17-unit apartment complex using pre-cut lumber packages resulted in 28,434 pounds of waste, or 2 pounds per square foot. This waste included the following recyclable materials of wood 16,169 pounds, cardboard 917 pounds and gypsum wallboard 6,997 pounds

From the information from Oikos as shown in Figure 2.9 on the types and quantities of construction waste, there are some important generalizations about residential construction waste:

- By weight or volume, wood, drywall and cardboard make up between 60 and 80 percent of jobsite waste.
- Vinyl and metals are generated in small quantities, but have good recycling value.
- Cardboard waste is increasing on most jobsites as more components, such as windows, appliances, cabinets and siding, are shipped to builders over long distances.

- Most wood waste is "clean" -- unpainted, untreated and recyclable. This usually includes dimensional lumber, plywood and particle board without laminates.
- Brick, block and asphalt shingle waste are insignificant in volume, but can be important in terms of weight.
- For most builders, the largest share of waste that could be considered hazardous is generated from painting, sealing, staining and caulking.
- Drive-by contamination (waste placed in a container by a party other than the builder or subcontractor) can be as much as 30 percent of the total volume hauled from a site.



**Figure 2.9: Types and Quantities of Construction Waste (Source: oikos.com)**

## **2.4 Waste Management Planning**

Good planning is the single most important part of construction waste management. Like anything else in construction, recycling is straightforward if you have a good blueprint, but becomes much more difficult and expensive if it's an add-on. Good planning allows you to identify all recyclable materials and know how you're going to manage them before the job starts. Good planning addresses how each waste material will be handled, what containers will be used and when they'll be on site, and where each material will be marketed. Good planning allows you to assess the costs and benefits of recycling and decide which materials to source separate, which to recycle as commingled debris, and which to discard as trash. Good planning covers communications, training, and troubleshooting, and lays out tracking and reporting procedures.

The Waste Management Plan is the document that lays out the start-to-finish strategy for job site recycling. It is prepared directly from the drawings and specifications for the job, and a good plan will closely follow these documents. The Waste Management Plan should include estimating types and quantities of wastes generated during each phase of the job, identify how each waste will be managed and marketed, provide an estimate of the overall job recycling rate, lay out plans for training, meetings, and other communications related to job-site waste management and provide troubleshooting instructions and contact information.

The Waste Management Plan is the cornerstone for successful construction waste recycling and reduction. It is a comprehensive document that provides all of the information needed by any individual on site to understand and achieve the waste management goals for the project. All of this can and should be done before you break ground or during the planning stage so that recycling is incorporated seamlessly into

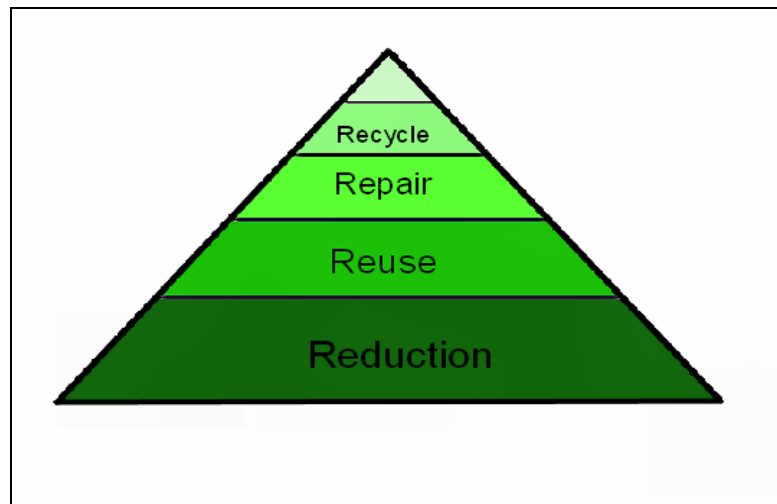
overall performance of the job. It's best if the Waste Management Plan is written and signed off on by all parties (owner, architect, and contractor) a month or more before site possession or the first day of site work. This allows time for all parties to participate in developing the plan, allows contractors and subcontractors to integrate recycling into their setup and work plans, and assures that training can be provided to supervisors and workers.

The Waste Management Plan is also a living document, used as a day-to-day reference just like blueprints and specifications. This fact cannot be overemphasized. Handling procedures or markets may change during the course of a job, these changes should be noted in modifications to the plan. As waste materials move from the site you will gather information on waste and recycling tonnages and costs. These should be matched against initial projections, variances should be analyzed, and a running recycling rate should be calculated. And you should publicize the recycling rate to laborers and trades. It's a good way to help boost morale, and keep workers striving to achieve your recycling goals (Construction Materials Management Guidelines, Feb1994).

## **2.5. Construction Waste Management**

Construction waste management may be defined as the discipline associated with the control of generation, recovering, processing and disposal of construction wastes in a manner that is in accord with the best principles of human health, economic, engineering, aesthetics, and other environmental considerations (Tchobanoglous, 1993). Construction waste management plays an important role in the managing of construction waste problem. The management approaches are different from one country to another, as are the levels of environment protection.

For example, some European countries have been practicing construction waste management based on prevention (minimization), recovery and restriction (reusing and recycling). Figure 2.10 shows the hierarchy of strategies for construction waste management.



\*The top triangle represents the waste fraction for disposal

**Figure 2.10: Hierarchy of Strategies for Construction Waste Management**  
(Source: CRC Construction Innovation, 2005)

Here are three simple actions to consider:

i) **Knowing what to throw** – From the standpoint of efficiency and liability, take a look at what and how much material ends up in job-site dumpster which can tell a lot about the crews and trade contractors in the site. Routinely check out job-site waste stream is one way of evaluating efficient use of materials.

ii) **Following the three R's** –The order of the three R's is reduce, reuse, and recycle.

With waste reduction, particularly framing waste, we can save twice – once with a reduced take-off list and again when pay for fewer disposals. Three of the largest waste

components on most job sites which are cardboard, wood, and drywall make up 75% of job-site waste can fully recyclable. While recycling outlets for drywall are rare and less than common for wood, there is a way to on-site grind these materials for use as erosion control and soil amendment at the job site. Also, if a non-profit reuses surplus or scrapped materials from a builder, the builder can claim the full value of the materials as a tax-deductible donation.

iii) **Investigating local conditions and options** – Builders represent just one group that needs to be involved in construction waste reduction. Waste haulers, recyclers, local building product manufacturers, landfill operators/owners, and local solid waste officials all bring their own issues and expertise to the table. We need to engage all of them to determine what might work in the community and on job sites. We should engage local home builder association to take a look at local construction waste management as a community opportunity to cost-effectively conserve natural resources and local landfill capacity.

### **2.5.1 The Needs of Construction Waste Management**

No one enjoys throwing materials away. But with all of the aspects of home building that require management today, why do we need to add waste? Construction waste management can enhance a builder's operation, as well as the image of the entire home building industry.

**Cost** – National Association of Home Builders, Washington (NAHB), survey reported that a typical builder pays \$511 per house for construction waste disposal. Your disposal costs may rise as old landfills close and new ones become more difficult to site and more

costly to design and operate. Even though disposal costs represent only about 0.5 percent of a home's total construction costs, consider that waste management costs could represent as much as five percent of your profit on a home. Waste reduction can reduce material purchases; recycling can finally reduce total disposal costs.

**Efficiency** – If materials are wasted on your job site, you have to pay twice, once at purchase and again when the usable material is hauled off for disposal. Knowing what materials end up in your dumpster can tell you a lot about how efficiently your crews and subcontractors are using materials that affect your bottom line. It's not difficult to find useful building materials "hidden" within the six-foot-high sides of site dumpsters.

**Resource Conservation** - Roughly 80 percent of a homebuilder's waste stream is recyclable. Homebuilders can do their part to conserve natural resources and landfill space by looking at their waste stream and seeing resources instead of refuse.

**Liability** - As a generator of some potentially hazardous materials such as certain paints, solvents and adhesives, you must protect yourself from any potential liability resulting from the unauthorized or illegal disposal of hazardous wastes. The general contractor bears some responsibility for any waste generated at jobsites. It is important to protect the company from any potential liability resulting from unauthorized or illegal disposal of wastes, particularly potentially hazardous wastes.

**Marketing** - As you begin managing your construction waste, take credit for being a good corporate neighbour and protecting resources. Let the buying public know that as you build, you are striving to protect the natural environment. Builders who make the effort to build resource efficient homes should take credit for their work. Distinction in the marketplace can lead to positive press and home sales.

### **2.5.2 Alternatives to Construction Waste Disposal**

For many builders, construction waste disposal is simply a necessary evil, an unavoidable cost of doing business. Here are four reasons why you might begin managing this stream of materials, just as you do other aspects of your business.

There are two main alternatives:

i) Organizational or governmental regulations that require reuse or recycle of specific building materials during a construction project.

ii) A waste management program implemented by an organization, which utilizes a waste manager who regulates the construction waste for reuse or recycle. Both options are effective and actually save money on the majority of construction projects. Construction contractors want to waste as little material as possible as it is costly for disposal and the materials themselves are costly.

Option one is best implemented on one-time construction projects and option two is best for construction companies where they are continually involved with construction projects. Option one does not involve a full time manager so it is less costly than option two but not as effective. Both options increase labor costs for separation of materials but these costs are offset by the money that is saved.

### **2.5.3 The Need for Building Waste Minimization**

In all communities it has always been common practice to retrieve valuable materials from the arising waste, e.g. metals and building materials. After some decades

with an extensive "use-and-throw-away" philosophy in the end of the last century it has now been recognized that we cannot continue this uninhibited use of natural resources and pollution of the world. It is necessary to change our habits and to revise former common practices within the building and construction industry, as well as within other industries, household's etc.

In the last decades many "green" movements arose, most of which were based on political and idealistic issues, and unfortunately made rather a limited impact on practical life. However, the World Bank have emphasized that the recycling of waste, the introduction and implementation of environmentally friendly technologies must be considered as one of the greatest technological challenges of our time. To encourage the achievement of these objectives the World Bank has clearly stated that the improvement and protection of the environment is a question of money and improvements should be supported by the developed countries. Another great technological challenge is to prevent, or at least reduce, damage to cities and to protect society from the causes of natural disasters. Natural disasters and technical - or man- made - disasters, especially wars, generate large amounts of building and industrial waste.

In many countries, industrialized as well as developing, construction waste is considered as harmless, inert waste, which does not give rise to problems. However, construction wastes constitute huge amounts and are often deposited without any consideration, causing many problems and encouraging the illegal dumping of other kinds of waste.

Furthermore construction waste typically includes a certain percentage of hazardous materials. Whether construction waste originates from clearing after natural disasters or from human-controlled activities the utilization of such waste by recycling can provide opportunities for saving energy, time, resources and money.

Furthermore, recycling and controlled management of construction waste will mean that less land is required for waste disposal and thus better opportunities will be available for the disposal of other kinds of waste. (Lauritzen, 2001)

At present very limited amounts of construction waste are recycled as high value materials, such as recycled aggregates in new concrete. The majority of construction waste is disposed of at dumping sites or recycled as crushed mixed filling materials for roads etc. Since the amounts of construction waste are constantly increasing, there are many reasons for focusing on methods which will promote recycling of construction waste (landfill fees in Europe and the USA are typically from US\$ 20-50 per tonne). Present results in Europe show very favorable recycling possibilities in this field. From a purely economical point of view the recycling of building waste is only attractive when the recycled product is competitive with natural resources in relation to cost and quality. Recycled materials will normally be competitive where there is a shortage of primary raw materials as well as suitable disposal sites. In other situations incentive or regulation are required to increase compositeness of recycling. With the use of recycled materials, economic savings in the transportation of building waste and raw materials can be achieved. In larger recycling projects, such as urban development, renovation of highways, or clearing of war/disaster-related damages, the total project cost will be dominated by transportation costs. These transportation costs involve the removal of demolition products and the supply of new building materials. In these cases the use of recycled materials is very attractive. (Lauritzen, 2001)

#### **2.5.4 The Important of Recycling**

Some benefits include: saving energy, saving land space, saving money, creating new jobs, reducing air and water pollution and preserving habitat for wildlife. That's why recycling is important and you should take a closer look at your life and how your

recycle materials used in your daily life. It takes less energy to process recycled materials than it does to use virgin materials. For example, it takes less energy to recycle paper from waste material than it does to create paper from new woodland, because there is no longer a need to cut down a new tree, process the wood from the tree and make it into paper.

What is so important about saving energy through recycling? Energy from non-renewable resources is protected and saved for future generations, money is saved when less energy is used. This can also mean more competitively priced goods and often pollution and emissions are reduced when less energy is used. For example, production of recycled paper uses 80% less water and 65% less energy, and produces 95% less air pollution than virgin paper production. Recycling reduces trash in landfill sites, which cuts down on the cost of waste disposal and the clearing of more land for new landfills when the current landfills become too full to store any more waste. Recycling is an easy and less expensive alternative to clearing more land for new landfills. For example, composting, recycling kitchen waste and yard waste into compost provides a means of free nutritious soil for gardening. In addition, most waste is not biodegradable. It stays in the landfills for years to come, just sitting there and piling up with the rest of the trash. Recycling would allow us to reuse the materials over and over again. Decomposing waste often release noxious gases and chemicals as it decomposes at landfill sites. These gas and chemicals create air pollution Air pollution is exactly what it sounds like, polluted air. When the chemicals leach into the groundwater this creates water pollution and our water is contaminated. In 2000, recycling of solid waste prevented the release of 32.9 million metric tons of carbon equivalent (MMTCE, the unit of measure for greenhouse gases) into the air.

Imagine how much pollution we could prevent if instead of landfills we had recycling centers We could breathe cleaner air and drink cleaner water. Recycling in the U.S. is a \$236 billion a year industry. More than 56,000 recycling and reuse enterprises

employ 1.1 million workers nationwide. If we created more recycling opportunities we would create more jobs and no one would have to lose their jobs either. Recycling also preserves wildlife. When fewer trees are cut down to make virgin material or to make space landfills, habitat for wildlife remains. More habitat for animals means less animal extinction. Despite what some may say, recycling is important and it can make a difference. We may not be able to solve our landfill and pollution problems anytime soon, but at least we can help keep them from getting worse.

Try it. It is really simple to do. Start with paper or plastic or both and take them to a recycling bin near your home. You don't have to drive extra to do it. Combine your recycling errands with other errands you have to do so you don't waste your time or your gas. For example, if you have to go grocery shopping fill up your car with your box of recyclable paper and dump it at the recycling bin near the store. Many grocery stores now have these bins available. If not ask them to start or participate in your neighborhood curbside recycling program. If there isn't one available get one started in your neighborhood. In 2001 United States residents, businesses and institutions generated more than 229 million tons of municipal solid waste (MSW). (EPA, Municipal Solid Waste in the United States: 2001 Final Report.)

This waste adversely affects the economy and the environment. Conventional methods of disposal involve landfilling. These landfills have limited capacity. As waste generation increases, new landfills must be built. Landfills are expensive to build and operate. The landfills are also highly subsidized by local governments and require significant land that then is no longer viable for wildlife habitat or residential, commercial, or recreational development. Waste negatively impacts the environment. Degradation of the natural landscape occurs through leaching from improperly lined landfills and from the extraction of resources for new materials. To counteract the amount of waste generation, communities have instituted recycling programs across the country. Recycling has economic and environmental benefits for communities. First,

recycling reduces the need for new landfills and their associated costs. Second, recycling can support industrial development as the recycled materials serve as raw materials for manufacturing and other uses. For example, recycled soda bottles are used in carpet manufacturing; steel contains 85 percent recycled content and recycled paper is milled for new paper products. By supplying raw materials to industry through the reuse of materials, recycling conserves resources by reducing the need to extract virgin resources or introduce new chemicals into the environment. By not disturbing existing natural resources and by reducing noxious manufacturing processes, recycling prevents emissions of many greenhouse gases and water pollutants. From a community and environmental preservation perspective, recycling conserves greenspace, protects habitat, and improves quality of life for residents in natural resource locations. Recycling also saves energy through avoided extraction and manufacture processes. This can be a particularly powerful strategy when one realizes that only 10 percent of all materials extracted are used in final products. This means that 90 percent of natural resources extracted for consumer use are disposed of as waste. From an economic perspective, such high values of unused material represent inefficiencies in the market. Missed opportunities exist where inefficiencies are present.

Recycling contributes to the economic base of communities. There is significant job creation and business development potential associated with recycling. Jobs in this field involve more than simple collection and separation. The remanufacture of recycled materials supports more than one million manufacturing jobs and adds more than \$100 billion in revenue. As companies seek to find new uses for recycled materials, research and development of 'greener' technologies require skilled individuals and significant capital investment. A wide variety of job skills are needed to develop this industry. Thus, the more robust are the recycling activities which include collection, separation, research, manufacture and resale and the more recycling can advance economic development.

In the United States, municipal solid waste recycling has become commonplace. The popular phrase, reduce, reuse, recycle has become a household mantra with millions of households separating their plastics, paper, cans and glass and using curbside pick-up, drop-off centers, buy-back centers, and deposit/refund programs. With over 9,000 curbside programs, 12,000 recyclable drop off centers, and 480 materials recovery facilities to process materials, recycling programs have reduced waste disposal needs by approximately 28 percent. Given this level of waste reduction, can communities breathe a sigh of relief? Are their waste woes over? Have they been able to maximize the economic potential associated with recycling? Twenty-eight percent is an impressive reduction in twenty years. However, it does not even represent a third of what could be recycled. This means there is a potential 72 percent of additional material that may be reused or recycled instead of ending up as landfill.

The US Environmental Protection Agency (USEPA) estimates that 42 percent of all paper, 40 percent of all plastic soft drink bottles, 55 percent of all aluminum beer and soft drink cans, 57 percent of all steel packaging, and 52 percent of all major appliances are now recycled. Certainly within these material streams, a larger percentage of recycling is possible. Further, these materials are only part of the waste stream. There are other materials that may have more impact when recycled. Construction and demolition debris materials are easily recyclable using existing infrastructure and make up larger concentrations of waste volume than cans, bottles, paper, etc.

(William McDonough and Michael Braungart. 2002. *Cradle to Cradle*. New York: Northpoint Press)

Construction and demolition waste is currently recycled at a rate of 20-30 percent. Project-based studies indicate that the potential for recycling is much higher more than 70 percent. While many construction and demolition materials are suitable for recycling, there are external factors that influence the spread of construction and demolition recycling. The value of recycled and salvaged goods in the marketplace,

labor costs for removal, sorting and processing, and relative disposal costs all play a role in expanding or contracting the market for reuse and recycled goods. Recycled and salvaged goods must be price competitive and perceived to be as desirable as or even more desirable than products produced from virgin materials. Competitive pricing is impacted by subsidies, incentives on virgin materials, and market demand. A California study revealed the ingrained subsidies and incentives for continued primary virgin materials markets. Ranging from tax incentives to material extraction from public lands, virgin materials are continually subsidized. Recycled goods or secondary materials do not benefit from similar policies that could facilitate their widespread use and resultant competitive pricing. Desirability for recycled materials is a reflection of the value placed upon these goods. This desirability can be affected by industry and consumer market knowledge and acceptance. As the market grows for the recycled goods, production costs and, ultimately, the price for such goods decrease. However, hesitancy to use recycled goods on the part of building code officials, contractors, and architects is often reflected in building codes. Most codes have not been designed to accommodate the use of salvaged and recycled materials. In a demolition field dominated by heavy machinery and constrained demolition timeframes, the process required for C&D recycling is affected by labor costs. Building deconstruction, the manual disassembly of structures and subsequent Deconstruction is used throughout this guidebook as an example of C&D recycling because it is the most basic form of recycling and reuse.

(US Green Building Council. Multiple case studies. [www.usgbc.org](http://www.usgbc.org))

Deconstruction activities are also combined with traditional recycling and some demolition for unsalvageable material reuse or recycling of their components is one method for preparing goods for secondary use. This labor intensive process affords maximum salvage and sorting opportunities as materials can be closely monitored and directed to their highest and best use. In some cases, deconstruction workers separate materials onsite. The sorted materials are then transported to recycling and reuse centers. Where space is limited, materials may be hauled to an off-site sorting facility where salvageable, recyclable, and unsalvageable materials are sorted and forwarded to their

respective destinations. Given the increased labor needs in removing and determining mode of secondary use, labor costs are traditionally higher for deconstruction and recycling. Costs for disposal of construction and demolition debris have the most impact on construction and demolition recycling. Tipping fees can make or break efforts to recycle. Regional and local variation in tipping fees affects the market for recycled materials. In an industry where construction profits are tight and demolition margins even tighter, when tipping fees for construction and demolition debris are low, there is no incentive to pursue alternatives to disposal of the waste. When it is initially cheaper to send construction and demolition debris to the landfill, rather than to a recycling facility, most contractors will choose the cost saving option.

An important concept is the first cost perspective. The way goods are valued is primarily by the initial investment. This perspective does not take into account lifecycle costs, environmental impacts, and social and human capital investments. Life cycle costs involve extraction costs, transportation costs, operating costs, and disposal costs of construction materials. These costs should all play into decision-making. However, the current economic framework does not encourage decision-makers to consider these long term and comprehensive costs. Environmental costs associated with disposal of potentially recyclable materials include: loss of habitat when pristine land is used for new landfills or there are expansions of existing landfills; increased extraction of raw materials for new construction products; leaching from landfilled items into soil and groundwater and poor air quality from demolition activities that increase dust and noise levels. Social costs include missed opportunities for job training and employment, community involvement in reshaping local built environments, and neighborhood stability (these are discussed in more detail in the following section). In calculating current tipping fees, these costs are not incorporated and, thus, tipping fees are not reflective of the true costs for disposal of construction and demolition debris. As discussed in the previous section, costs have an impact on the feasibility of construction and demolition recycling. As project disposal costs can range from .5-30 percent of a project, construction costs savings motivate the construction and demolition industry to

implement new recycle and reuse construction and demolition materials. Helping Landfill liners are guaranteed for 50 years. Contractors to understand that using new materials and discarding scrap from them means developers pay for materials twice—first for the purchase and then again for disposal. Case studies indicate that 80 percent of building materials could be reused or recycled.

Communities requiring construction and demolition waste management plans that utilize recycling can help to reduce development costs of new and rehabilitated projects. These savings can, in turn, stimulate additional development and improve the bottom line for construction firms. Current economic and political climates value virgin materials more highly than secondary materials. This is based on the use of first costs for analysis, rather than including life cycle and social and environmental costs. For communities interested in economic development, that is “raising standards of living and improving the quality of life through a process that specifically lessens inequalities in [metropolitan] development and the [metropolitan] population’s standard of living”, construction and demolition recycling is a strategy to be combined with other revitalization efforts

### **2.5.5 Recycling Barriers**

In order to reach the goals of construction waste management, it is necessary that all barriers and obstacles are detected and considered. The overcoming of these barriers must be planned and carried out through a long-term action plan combined with adequate research and development. Implementation of recycling systems requires that the necessary legal, economic and technical instruments are made available. (Lauritzen, 2001)

If the consumption of building materials is regulated solely by the market economy the choice between recycled and new materials depends upon price and quality. The quality of concrete with recycled aggregates can be the same as that of concrete with primary natural aggregates, but recycled concrete aggregates are traditionally regarded with suspicion. Hence, recycled concrete materials will often only be preferred where the price of such aggregates is considerably lower than that of the natural materials, even when the recycled aggregates meet the expected specifications. (Lauritzen, 2001)

#### **2.5.6 Policies and strategies**

Construction waste must be considered as a specific individual type of waste associated with the building and construction industry, which should be regulated and handled specifically. It is important to get the industry itself to take responsibility for proper management and handling of the construction waste. Generally, the building and construction industry is relatively conservative, and changes in normal procedures often take time and require long-term policies and strategies. One of the most critical barriers is the many public entities involved in management of building waste. Usually, it is the environmental departments and offices who prepare the policies and issues concerning waste recycling and reduction, whereas the policies and issues concerning the building and construction activities themselves are controlled by departments and offices which are concerned with housing, construction and public works.

To coordinate the interests of all parties, particularly with respect to the implementation of cleaner technologies in the industry, it is necessary that long term policies and strategies are prepared and implemented. Finally, a monitoring and evaluation system must be prepared and maintained continuously. It is recommended that monitoring of the construction waste management should be incorporated in the general monitoring system. In Denmark a nationwide solid waste reporting system has

been installed. The system receives detailed information on the handling of all construction and demolition waste in the country. (Lauritzen, 2001). Owing to tradition and psychological barriers the general attitude towards recycling in the building and construction industry is largely prohibitive towards the utilization of recycled materials. Therefore, it is of great importance that recycled materials are officially certified and accepted by all parties in the building and construction industry. It is recommended that considerable emphasis be placed on specifying the fields of utilization of recycled construction waste and setting quality standards for recycled materials. These must be in accordance with the local demand in order to improve confidence in the recycled materials and solve problems regarding the responsibility of using such materials. (Lauritzen, 2001)

### **2.5.7 Reduce, Reuse, and Recycle**

Waste reduction, reuse and recycling are valuable components of the solid waste management system in the United States. They are slowly becoming better understood and more and more people are participating in programs today. Recycling and waste reduction are easy, hands-on activities that help protect our environment and activities that provide a number of benefits.

#### **2.5.7.1 Reducing waste, reusing and recycling conserve landfill space**

The best approach to managing waste is called "source reduction" - not creating it in the first place. This means reducing the amount of trash you discard, and reusing containers and products instead of throwing them away. While the overall number of landfills across the nation is decreasing, the existing ones are getting bigger to

accommodate the growing waste generated by Americans. According to the U.S. Environmental Protection Agency (EPA), the United States leads the industrialized world in municipal solid waste generation: each person currently generates an average of 4.62 pounds of waste per day. Canada and the Netherlands come in second and third, with 3.75 and 3 pounds per person per day, respectively. Germany and Sweden generate the least amount of waste per capita for industrialized nations, with just under 2 pounds per person per day. The EPA has stated that recycling is one of the best environmental success stories of the late 20<sup>th</sup> century. Recycling, which includes composting, diverted nearly 70 million tons of material away from landfills and incinerators in 2000, up from 34 million tons in 1990 doubling in just 10 years.

#### **2.5.7.2 Recycling has the potential to save money**

Recycling does cost money, but so does waste disposal. Waste disposal costs include the construction of waste transfer stations and incinerators, landfill fees, groundwater monitoring, personnel and other operating costs, fleet maintenance, and other expenses. Recycling can reduce some of these costs, and communities can even make money by selling certain recyclable materials. While markets for recovered materials fluctuate depending on a variety of economic conditions, buying products made from recycled materials helps create a steady market incentive for manufacturers.

#### **2.5.7.3 Waste reduction and recycling save natural resources**

By reusing materials and re-manufacturing them into new products we are reducing the amount of virgin natural resources that we need to use. For example, for every ton of recycled paper that we use we can save 17 trees. Recycling also reduces waste from mining and excavation. For example, one ton of glass produced from raw

materials creates 384 pounds of mining waste. For every ton of glass that is recycled, 1,330 pounds of sand, 433 pounds of soda ash, 433 pounds of limestone, and 151 pounds of feldspar are conserved.

#### **2.5.7.4 Recycling saves energy**

Energy savings can be seen when most materials are recycled. One example of valuable energy savings is the recycling of aluminum cans. It takes 95 percent less energy to recycle an aluminum can than it does to make a new can from bauxite ore. According to the U.S. Environmental Protection Agency, in 2000, recycling resulted in annual energy savings of at least 660 trillion BTUs, which equals the amount of energy used in 6 million households annually. In 2005, recycling is conservatively projected to save 900 trillion BTUs, equal to the annual energy use of 9 million households.

#### **2.5.7.5 Recycling reduces pollution and impacts global warming**

The manufacture, distribution, and use of products - as well as management of the resulting waste - all result in greenhouse gas emissions, which trap heat in the upper atmosphere. Increased concentrations of these gases can contribute to global climate change. By reusing goods and purchasing recycled products, less energy is needed to extract, transport and process raw materials. When energy demand decreases, fewer fossil fuels are burned and less carbon dioxide is emitted into the atmosphere. Trees absorb carbon dioxide from the atmosphere and store it in wood in a process called "carbon sequestration." Waste prevention and recycling paper products allows more trees to remain standing in the forest, where they can continue to remove carbon dioxide from the atmosphere and help regulate our climate.

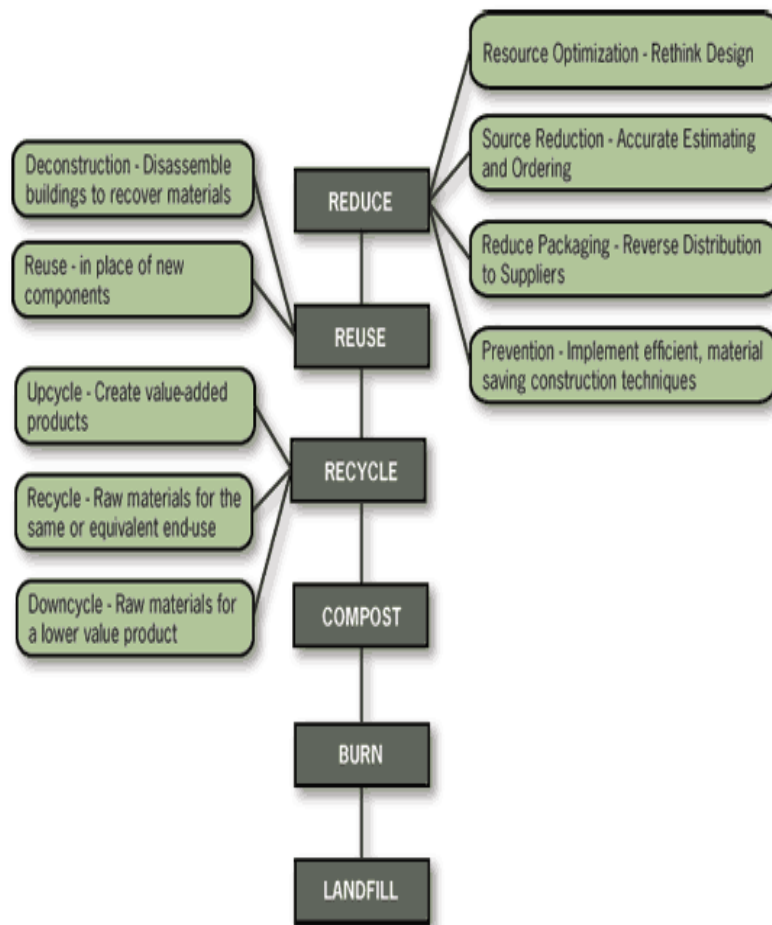
### **2.5.7.6 Recycling creates jobs**

In a recent study, the Institute for Local Self-Reliance, a Washington based non-profit, estimated that nine jobs are created for every 15,000 tons of waste that is recycled while only one job is created for every 15,000 tons of waste that is landfilled or incinerated. The U.S. EPA has launched Jobs through Recycling initiative to help inform communities about the economic and business development benefits obtained as a result of recycling programs and industries. According to their U.S Recycling Economic Information Study, more than 56,000 recycling and reuse establishments in the United States employ approximately 1.1 million people, generate an annual payroll of \$37 billion, and gross \$236 billion in annual revenues. According to the report, the number of workers in the recycling industry is comparable to the automobile and truck manufacturing industry and is significantly larger than mining and waste management and disposal industries. In addition, wages for workers in the recycling industry are notably higher than the national average for all industries.

Waste streams vary greatly between different construction phases. However, in many cases overlapping of the construction phases was observed which effect the type of the waste arise on the specific stage of the project. It was observed that at roofing stage, waste stream is being produced due to packaging and card board waste. It should be noted that it is norm to work on finishing while works are on going on the roofing to speed up the construction. However most packaging waste been produced by packaging of the roofing tiles, floor tiles, etc. Second highest waste stream at roofing stage was insulation material. Rubble was most prominent waste stream at plastering, painting stages and finishing stages. During waste arising data collection survey it was observed that, the most of waste arises are on the structure and fitting stages of construction.

Figure 2.11 shows the flowchart for construction waste management.

(U.S. Environmental Protection Agency, 2000)

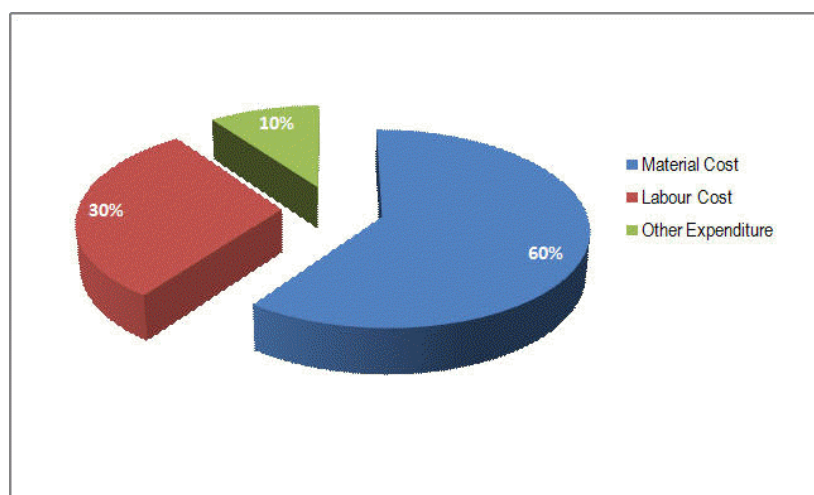


**Figure 2.11: Flowchart For Construction Waste Management**  
(U.S. Environmental Protection Agency, 2000)

## 2.6 The Cost of Construction Material

Construction Materials like cement, iron steel goods, bricks and development materials like pipes and petroleum products plays an important role in the development and construction projects. As such, an attempt has been made to estimate quantity, cost of construction and development materials and study supply provisions of these

materials while formulating periodic plan. As shown in Figure 2.12 material cost is 60% of the total construction cost.



**Figure 2.12: Cost of construction (Source: NAHB Research centre)**

The cost of construction material depends on a few factors. Among the major categories are purchase costs, order cost, holding costs, and unavailable cost. These cost categories are interrelated since reducing cost in one category may increase cost in others. The costs in all categories generally are subject to considerable uncertainty. The purchase cost of the material is the unit purchase price from an external source including transportation and freight costs. For construction materials, it is common to receive discounts for bulk purchases, so the unit purchase cost declines as quantity increases. These reductions may reflect manufacturers' marketing policies, economies of scale in the material production, or scale economies in transportation. There are also advantages in having homogeneous materials. For example, a bulk order to insure the same color or size of items such as bricks or tiles may be desirable. Accordingly, it is usually desirable to make a limited number of large purchases for materials. In some cases, organizations may consolidate small orders from a number of different projects to capture such bulk discounts; this is a basic saving to be derived from a central purchasing office. The cost of materials is based on prices obtained through effective

bargaining. Unit prices of materials depend on bargaining leverage, quantities and delivery time. Organizations with potential for long-term purchase volume can command better bargaining leverage. While orders in large quantities may result in lower unit prices, they may also increase holding costs and thus cause problems in cash flow. Requirements of short delivery time can also adversely affect unit prices. Furthermore, design characteristics, which include items of odd sizes or shapes, should be avoided. Since such items normally are not available in the standard stockpile, purchasing them causes higher prices. Shipment sizes and also will affect the transportation costs. Shipment by the full load of a carrier often reduces prices and assures quicker delivery, as the carrier can travel from the origin to the destination of the full load without having to stop for delivering part of the cargo at other stations. Avoiding transshipment is another consideration in reducing shipping cost. While the reduction in shipping costs is a major objective, the requirements of delicate handling of some items may favor a more expensive mode of transportation to avoid breakage and replacement costs.

The order cost reflects the administrative expense of issuing a purchase order to an outside supplier. Order costs include expenses of making requisitions, analyzing alternative vendors, writing purchase orders, receiving materials, inspecting materials, checking on orders, and maintaining records of the entire process. Order costs are usually only a small portion of total costs for material management in construction projects, although ordering may require substantial time.

The holding costs or carrying costs are primarily the result of capital costs handling, storage, obsolescence, shrinkage and deterioration. Capital cost results from the opportunity cost or financial expense of capital tied up in inventory. Once payment for goods is made, borrowing costs are incurred or capital must be diverted from other productive uses. Consequently, a capital carrying cost is incurred equal to the value of the material during a period multiplied by the interest rate obtainable or paid during that period. Note that capital costs only accumulate when payment for materials actually occurs, many organizations attempt to delay payments as long as possible to minimize

such costs. Handling and storage represent the movement and protection charges incurred for materials. Storage costs also include the disruption caused to other project activities by large inventories of materials that get in the way. Obsolescence is the risk that an item will lose value because of changes in specifications. Shrinkage is the decrease in inventory over time due to theft or loss. Deterioration reflects a change in material quality due to age or environmental degradation. Many of these holding cost components are difficult to predict in advance. A project manager knows only that there is some chance that specific categories of cost will occur. In addition to these major categories of cost, there may be ancillary costs of additional insurance, taxes, or additional fire hazards.

The unavailability cost is incurred when a desired material is not available at the desired time. In manufacturing industries, this cost is often called the stock out or depletion cost. Shortages may delay work, thereby wasting labor resources or delaying the completion of the entire project. Again, it may be difficult to forecast in advance exactly when an item may be required or when a shipment will be received. While the project schedule gives one estimate, deviations from the schedule may occur during construction. Moreover, the cost associated with a shortage may also be difficult to assess. If the material used for one activity is not available, it may be possible to assign workers to other activities and depending upon which activities are critical, the project may not be delayed. (Carnegie Mellon University, Pittsburgh, 1998)

Master Builders Association Malaysia (MBAM), Real Estate and Housing Developers' Association Malaysia (REHDA), Persatuan Kontraktor Melayu Malaysia (PKMM) and Persatuan Kontraktor India Malaysia (PKIM) are concerned over the negative impact of the recent increase in building material costs due to external pressures. In the cases of steel bar and cement prices where price ceilings are imposed, rising world prices above the price ceiling have resulted in local millers averting supply to export markets, creating an artificial shortage locally. At these times, local builders

have been forced to purchase above the ceiling price. Hard pressed to keep to construction schedules, local builders are being forced to purchase at artificially inflated prices. To make things worse, import controls do not allow cheaper alternatives to be sourced from overseas markets, allowing local steel millers to charge unreasonably higher prices. Contractors have been absorbing price increases of materials as a typical cost of doing business. However, with current volatility in prices, contractors are no longer able to absorb price fluctuations on their own without facing serious cash flow problems. (MBAM Press Release 4 April 2007)

## 2.7 Previous Research

In the research paper of Siti and Noor, titled *Approach in construction industry: A study on prefabrication method as a tool for waste minimization*, presented in the International Conference on Environment Research and Technology (ICERT 2008), their method of collecting data are done at site visit. Weekly site visit was performed to collect data and gain extra information for selected site projects. These site projects were selected according to the location and construction methods that were used. The calculation and analyzing of the construction waste follows the method employed by Poon et al (2001). Data collection includes raw materials consumption consists of cumulative order quantity and cumulative work done. Truck volume (m<sup>3</sup>) and total number of truck loads for waste proposal was also determined. Application of “waste index” formula to count the amount of waste produced and wastes percentage level.

A\* Formula of measurement of total waste produced from overall project.

V = truck volume (m<sup>3</sup>)

N = total number of loads for waste proposal

W = total waste generated by the project (m<sup>3</sup>) = (V) x (N)

C = Waste index = W / GFA (i.e. 1m<sup>2</sup> area of GFA generates (c) m<sup>3</sup> of waste).

B\* Formula of measurement of wastage percentage level

(1) Cumulative order quantity

(2) Cumulative work done

(3) = (1) – (2) = wastage

(4) = (3) / (2) wastage % including disposed and reused material

(Source: Siti Naziera Mokhtar and Noor Zalina Mahmood, 2008)

In the research paper of Lau, Whyte and Law, titled *Composition and Characteristics of Construction Waste Generated by Residential Housing Project* from the journal of *Int. J. Environ. Res.*,2(3): 261-268, Summer 2008 ISSN: 1735-6865, their method of collecting and analyzing data are as follow:

The layouts of the construction waste generated on the construction site were divided into four forms: stockpiled, gathered, scattered and stacked. Quantities of the construction waste generated, in terms of weight, for a particular layout were determined through the product of its respective estimated volume and estimated unit weight. For stockpiled waste, it was assumed to stay in the form of rectangular base pyramidal shape (Figure 2.13). The volume ( $V_s$ ) of a stockpiled waste was taken as the volume of a rectangular base pyramidal shape, where  $V_s = 1/3 (B \times L \times H)$ . For gathered waste, it was assumed to stay in the form of rectangular prism (Figure 2.14) on the ground surface. The volume of gathered waste ( $V_g$ ) was taken as the volume of rectangular shape, where  $V_g = L \times B \times H$ . The total of each construction waste weight are then estimated through the volume obtained.



**Figure 2.13: Stockpiled waste**



**Figure 2.14: Gathered waste**

In the research of Siti et al, 2008, the findings was based on the total general construction waste generated between the residential and commercial industry during the construction period for a pre-fabricated project site. In the research of Lau et al, 2008, the findings were based on the total construction waste generated for each type during the project compared to the development area.

## **CHAPTER III**

### **METHODOLOGY**

#### **3.1 Introduction**

This chapter discussed on the methods employed in achieving the study objectives. As stated on the objectives in chapter 1, the foremost study is to identify and quantify the types of construction waste. A thorough planning had been organised on the study in proper sequence to ensure a reliable and good result on the study. In this research methodology, it includes the range of indicating the research location, the types and selling price of the luxury landed properties. This will further explained on method and types of data to be collected. With the collected data, a method of analysing will be explained in order to obtain the desired result.

#### **3.2 Methodology**

This case study was carried out at two construction site that are a double storey semi-detached houses and double storey terrace houses.

The project for the double storey semi-detached houses in this case study was the construction and completion of 48 units of double storey semi-detached houses situated at Damansara Idaman, Petaling Jaya, Selangor Darul Ehsan. The construction contract value for this project is RM29,100,000.00 and the completion duration is 16 months. It consists of 3 types of double storey semi-detached houses varying from 2600sq feet to 3500sq feet in built-up area. The selling prices were ranged around RM1.7m to RM2.3m for each unit, which was built in a prime freehold land. It will be a gated community including of 6 show-units, a guardhouse, a TNB sub-station, landscape garden and a clubhouse, which was previously built.

The project for the double storey terrace houses in this case study was the construction and completion of 179 units of double storey terrace houses situated at 7th mile Jalan Gombak, Selangor Darul Ehsan. The construction contract value for this project is RM24,665,086.43 and the completion duration is 15 months. It consists of 2 types of double storey terrace houses with a built area of 1,961sq feet and 2,173sq feet respectively. The selling prices were ranged around RM328,800.00 to RM355,000.00 for each unit, which was built in a prime freehold land.

### **3.2.1 Data Collection**

Data on the construction waste are obtained from the identified site by site observing, monitoring, segregation and measurement. In this case study, only 6 units of double storey semi-detached houses and 12 units of double storey terrace houses with a built-up area of 3,000ft<sup>2</sup> and 2,173ft<sup>2</sup> respectively are chosen for the data collection. Site discussion was conducted with the contractors and site supervisors on the sites visit. The survey basically questions the characteristics of waste generated during the construction process, including the sources and causes of waste generation, and steps taken to reduce

it. In addition, regular site monitoring is conducted for this research. Site inspection was carried out at least once per week on the study sites. Associated sources and causes of construction waste generation at different construction stages were documented.

The construction waste generated from these construction sites was collected by the method of segregation. The construction waste generated on the construction site was divided into the most likely six types which was wood, concrete, bricks, metal, cardboard and others. Standard waste bin as shown in Figure 3.1 will be provided for each type of waste to be dispose. The dimension of this waste bin is 12feet long, 6feet width and 2.5feet high. The volume of each bin is 180ft<sup>3</sup> or 6.67yd<sup>3</sup>. Every full load of each type of waste was recorded before haulage for disposal. With this the total bin for each type of waste was recorded and the total volume of each waste can be obtained.



**Figure 3.1: Standard Waste Bin**

The typical waste density was estimated by using Table 3.1 and Table 3.2. In this study, the density used for wood, concrete, bricks metal, cardboard and other mixed waste was 300lb/cuyd, 140lb/cuft, 120lb/cuft, 490lb/cuft, 100lb/cuyd and 350lb/cuyd respectively. With this, the quantities of the construction waste generated, in terms of weight, for each particular type were determined. It was calculated by multiple the total waste volumes with the estimated waste density.

**Table 3.1: Volume-weight conversions. (Source: Yost and Lund, 1997).**

<b>Material</b>	<b>Conversion Rate</b>
Wood	300 lb/cu yd. 6.7 cu yd./ton
Cardboard	30-100 lb/cu yd. 20-50 cu yd./ton
Drywall	400 lb/cu yd. 5 cu yd./ton
Rubble	1400 lb/cu yd 1.4 cu yd./ton
Mixed waste	350 lb/cu yd. 5.7 cu yd./ton

**Table 3.2: Typical construction material density. (Source: Hoke, 1988)**

<b>Materials &amp; Description</b>	<b>Density (lb per cu ft)</b>
Gypsum or plaster board	50
Plywood	34
Sheathing, fiberboard	18-25
Particleboard	40
Blanket and Batt Insulation mineral wool, fibrous form	0.3-2.0
Boards and Slabs Insulation Cellular glass	8.5
Glass fiber	4-9
Expanded rubber (rigid)	4.5
Expanded polyurethane (R-11blown)	1.5
Acoustical tile	18-23
Cement mortar	116
Sand & gravel or stone aggregate	140
Stucco	116
Brick, common	120
Brick, face	130
Granite, marble	150-175
Aluminum	171
Brass	524-542
Copper	550-555
Iron, gray cast	438-445
Iron, pure	474-493
Lead	704
Steel	490
Cement plaster, sand aggregate	116
Gypsum plaster	45
1-ply membrane roofing	83
Asphalt roll roofing	70
Asphalt shingles	70
Built-up roofing	70

The extra construction material or material wastages was determined by comparing the quantities of construction material that was obtained from the contract document and the actual site usage quantities. The cost of the construction material was calculated based on the actual purchasing price of year 2008 which was RM60.00 for a piece of plywood, RM130.00 for a cubic meter of grade 25 ready mixed concrete, RM0.35 for a piece of common brick and RM2100.00 for a metric ton of steel bar. The analysis and detail result was described on the following chapter.

## **CHAPTER IV**

### **ANALYSIS AND RESULT**

#### **4.1 Introduction**

Construction and Demolition waste is produced by construction, renovation and demolition activities. The composition of the waste is variable and depends on the type of construction and demolition activity. Construction waste is anything generated as a result of construction and then abandoned, regardless of whether it has been processed or stockpiled. It comprises surplus materials from site clearance, excavation, construction, refurbishment, renovation, demolition and road works. As explain in the research methodology, the most likely waste that will be generated in the building construction such as wood, concrete, bricks, metal, cardboard and mixed rubbish will be collected. The quantity of construction waste collected were recorded accordingly and will be analysed and described in this chapter. The comparison of construction waste, waste generated per square feet of as built area and material wastages cost between the double storey semi-detached and terrace houses will also be made.

## 4.2 Construction Waste

Following are the construction waste collected as described earlier. Wood waste accounts for 40 percent to 50 percent of the residential construction waste stream. Wood waste can be used for in composting operations, animal bedding, landfill cover, some building products, and as an industrial fuel source. For many of these applications, however, there is concern with regard to the adhesive content of engineered wood products such as plywood, oriented strandboard (OSB), or wood I-beams. Up to half of jobsite, wood waste can be engineered wood product waste. A local forum would be helpful in identifying recycling obstacles and opportunities. Wood refers to waste resulted from timber products, such as formwork, falsework, plywood, dimensional lumber, framing, roof truss and others. It is the highest waste stream by means of total weight produced at site. Wood is widely used in the construction industry and due to the cheap material cost and the cheap labour force in the local construction industry, historically regarded as an expendable resource.

Concrete waste is also one of the major waste streams in construction waste. The concrete waste component comprises one of the highest percentages of construction waste at site. Brick is one of the main components of construction waste. Local unloading methods and the hacking-off walls for the mechanical and electrical services play a part in the generation of brick waste. The demolition of wrongly constructed wall also contributed for the waste.

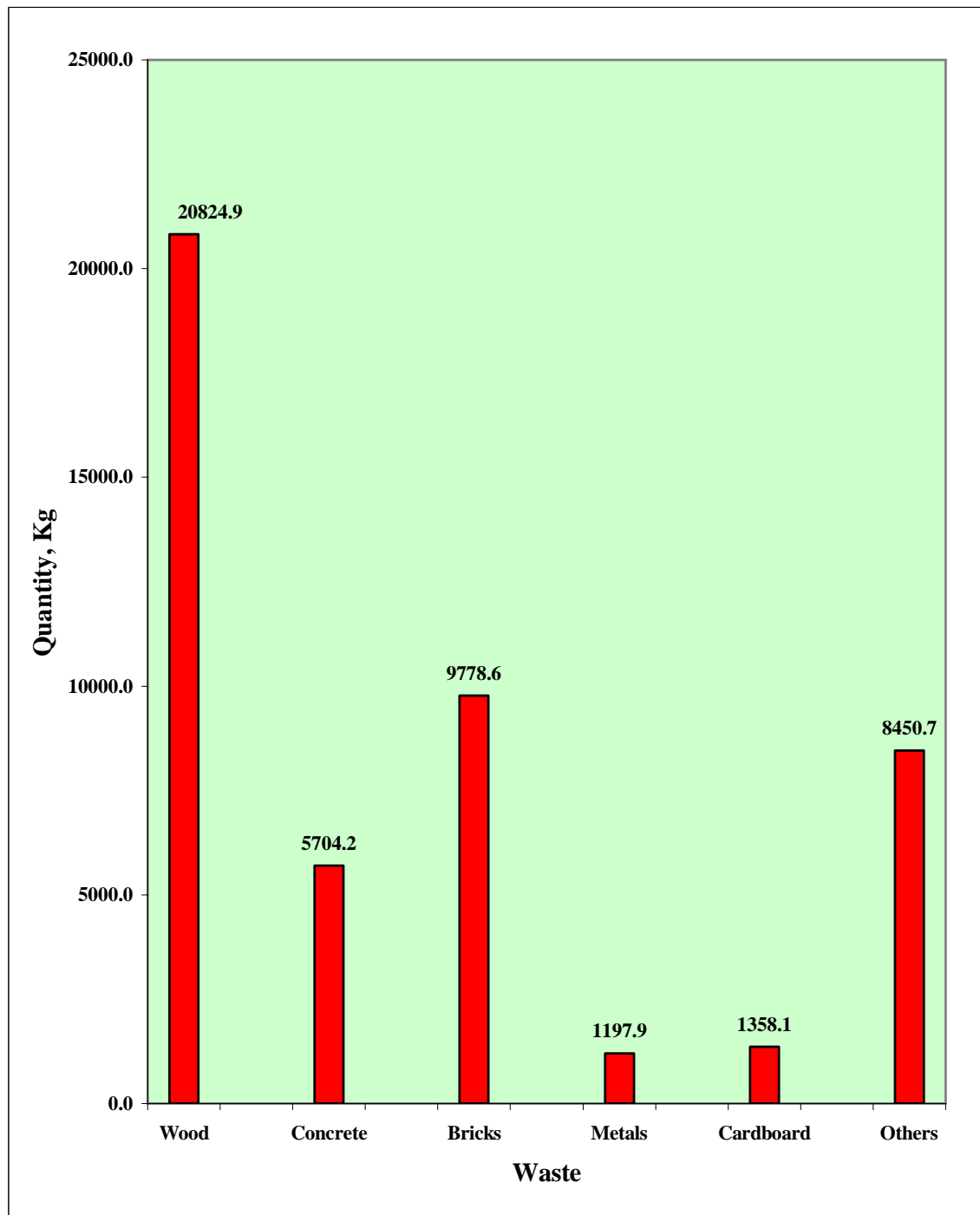
Metal refers to waste generated from ferrous or non-ferrous materials, such as reinforcing bars, pipes, steel, aluminium, copper, brass and others. It is among the lowest waste generated from the six main components of construction waste. It is mainly due to the relatively high cost and high recycles value in the local market. Off cuts of reinforcement are usually collected and placed properly for future use or recycle. Other

metal products, such as steel roofing sheet, aluminium panels and frames, made up an insignificant amount of waste around the site and were normally recollected.

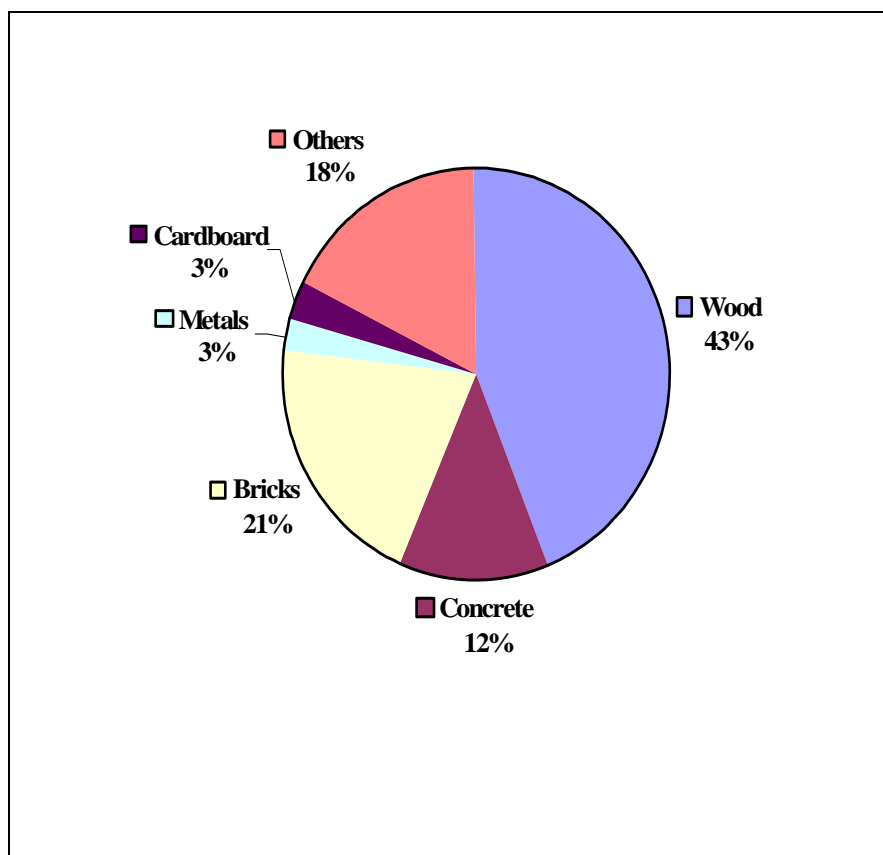
Corrugated cardboard is the most common building product used as packaging material. Quantities are increasing as more and more building components are delivered to job sites as finished products. Mixed debris is the common commodity on all construction sites. No matter how many materials are source-separated, there will always be a mixed debris container as well. On some sites, mixed debris may be the recycling option for most of the waste. For example, in an urban multi-story building with room for one chute and one container on the ground, there may be no option but to fill the container with mixed debris. Schedule, demolition methods, job size, or site limitations are all factors that can push much or most of the waste stream into mixed debris. Other arisings usually refer to waste generated from finishing works, such as packaging of materials, ceramic tiles, roof tiles, insulation and others.

#### **4.2.1 Double Storey Semi-Detached House**

The total construction waste collected for the six units of double storey semi-detached houses were 47,314.4kg which consists of 20,824.9kg of woods, 5704.2kg of concretes, 9778.6kg of bricks, 1197.9kg of metals, 1358.1kg of cardboard and 8450.7kg of other wastes. This result was shown in Figure 4.1. In terms of percentage the major contribution of construction waste was shown in Figure 4.2 are from wood 43%, followed by brick 21%, others waste 18%, concrete 12%, metal 3% and cardboard 3% respectively.



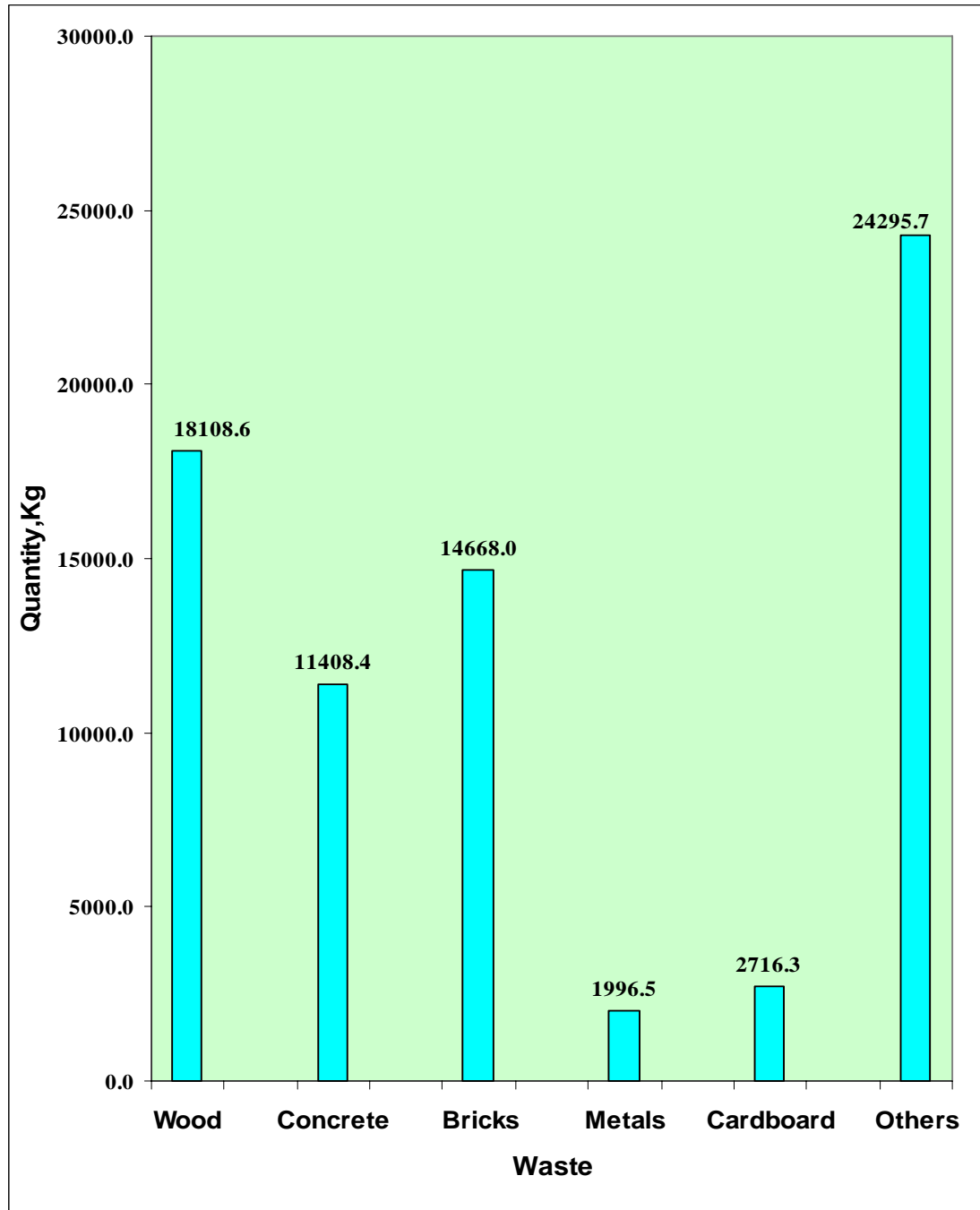
**Figure 4.1: Total Construction Waste For Double Storey Semi-Detached Houses (6 units)**



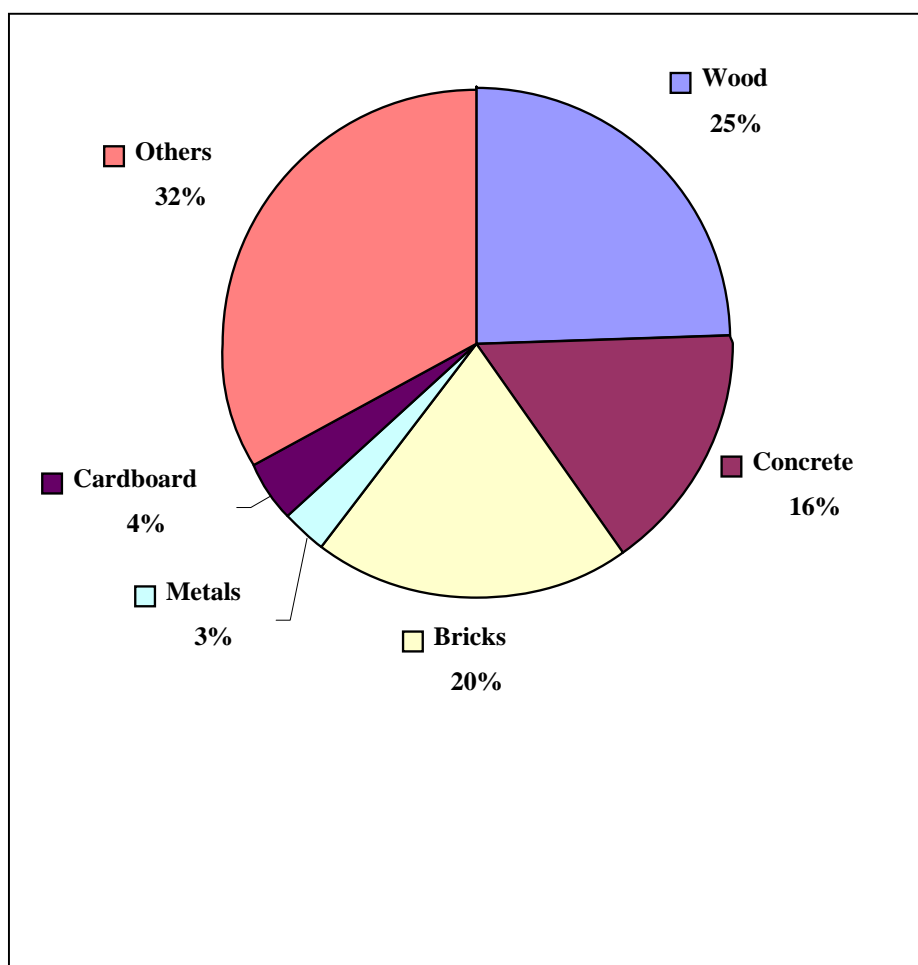
**Figure 4.2: Percentage of Construction Waste for Double Storey Semi-Detached Houses**

#### 4.2.2 Double Storey Terrace House

The total construction waste collected for the twelve units of double storey terrace houses were 73,193.4kg which consists of 18,108.6kg of woods, 11408.4kg of concretes, 14668.0kg of bricks, 1996.5kg of metals, 2716.3kg of cardboard and 1056.3kg of other wastes. This result was shown in Figure 4.3. In term of percentage the major contribution of construction waste was shown in Figure 4.4 are from other waste 32%, followed by wood 25%, brick 20%, concrete 16%, cardboard 4% and metal 3% respectively.



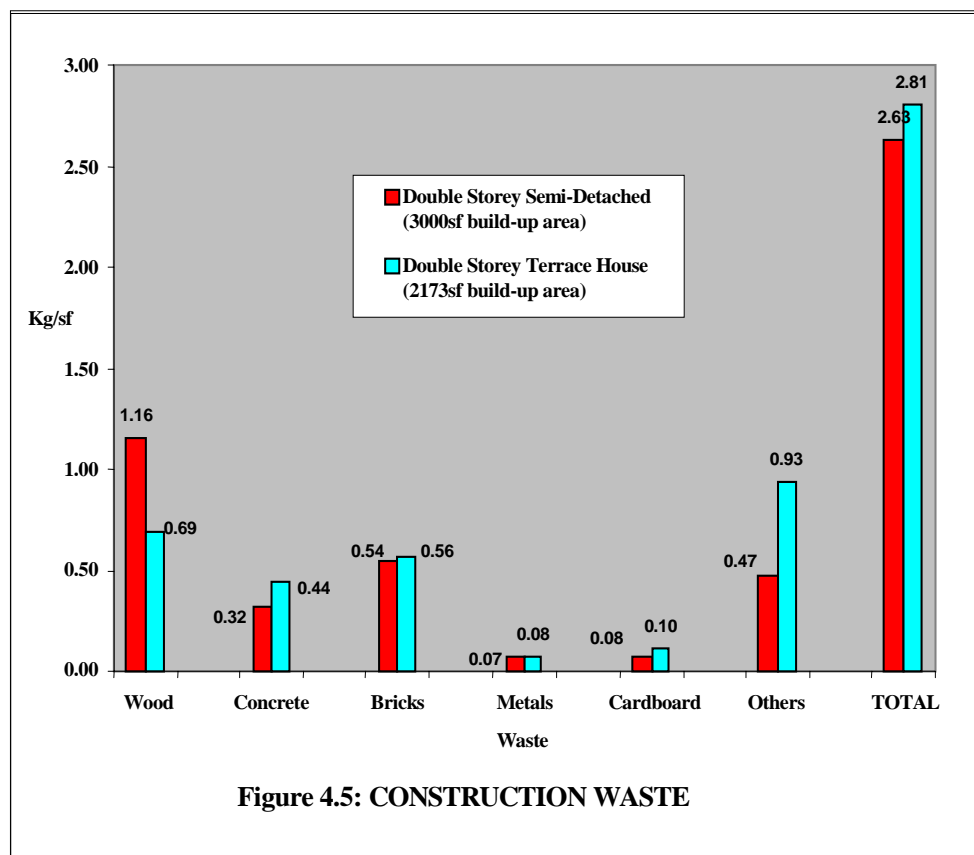
**Figure 4.3: Total Construction Waste for Double Storey Terrace House (12 units)**



**Figure 4.4: Percentage of Construction Waste for Double Storey Terrace House**

### 4.2.3 Construction Waste Per Square feet

As shown in Figure 4.5, the construction waste generated on double storey semi-detached and double terrace houses were 2.6kg/sqft and 2.8kg/sqft respectively. This indicates that the waste generated by the terrace houses construction were 0.2kg/sqft more than the semi-detached houses.

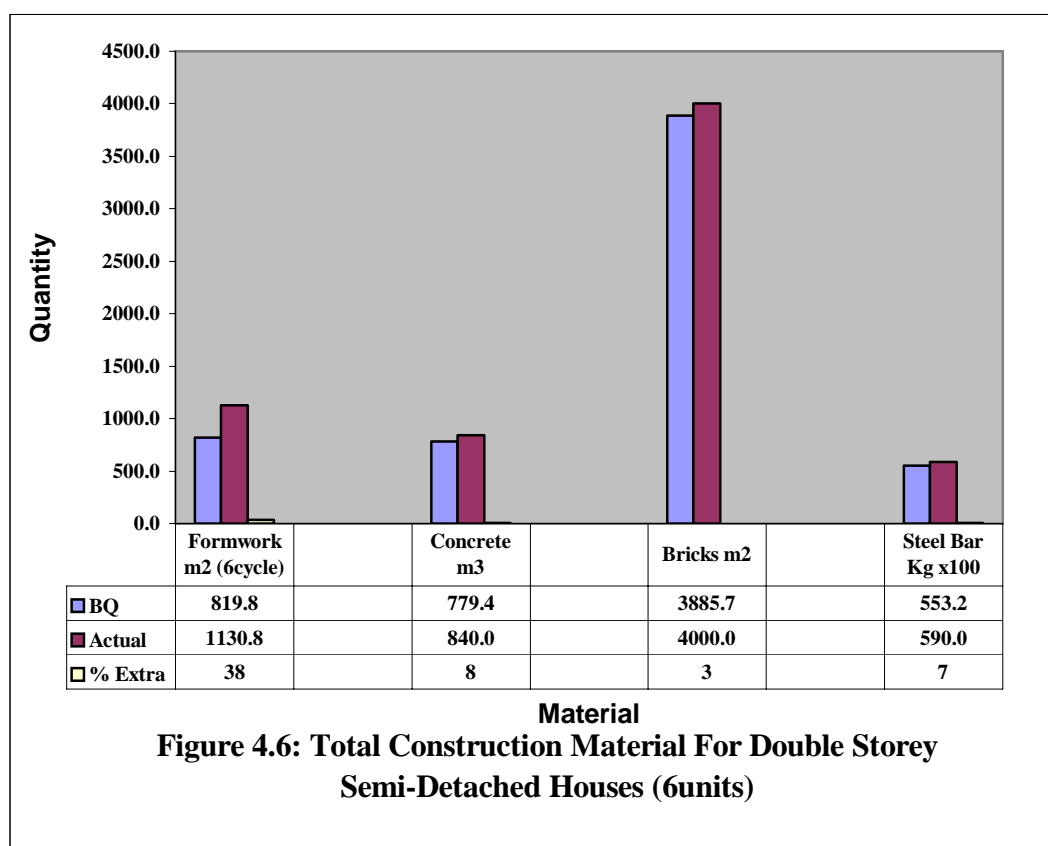


In semi-detached houses, the major contribution of waste, woods were 1.16kg/sqft but in terrace houses are only 0.69kg/sqft. These purely are from the formwork and all unwanted timber backing such as in timber pellets for bricks and tiles. Where else the major contribution of waste for terrace houses was others, 0.93kg/sqft compared to semi-detached houses as 0.47kg/sqft. The concrete wastes also have great differences in semi-detached and terrace houses, which are 0.32kg/sqft and 0.44kg/sqft respectively.

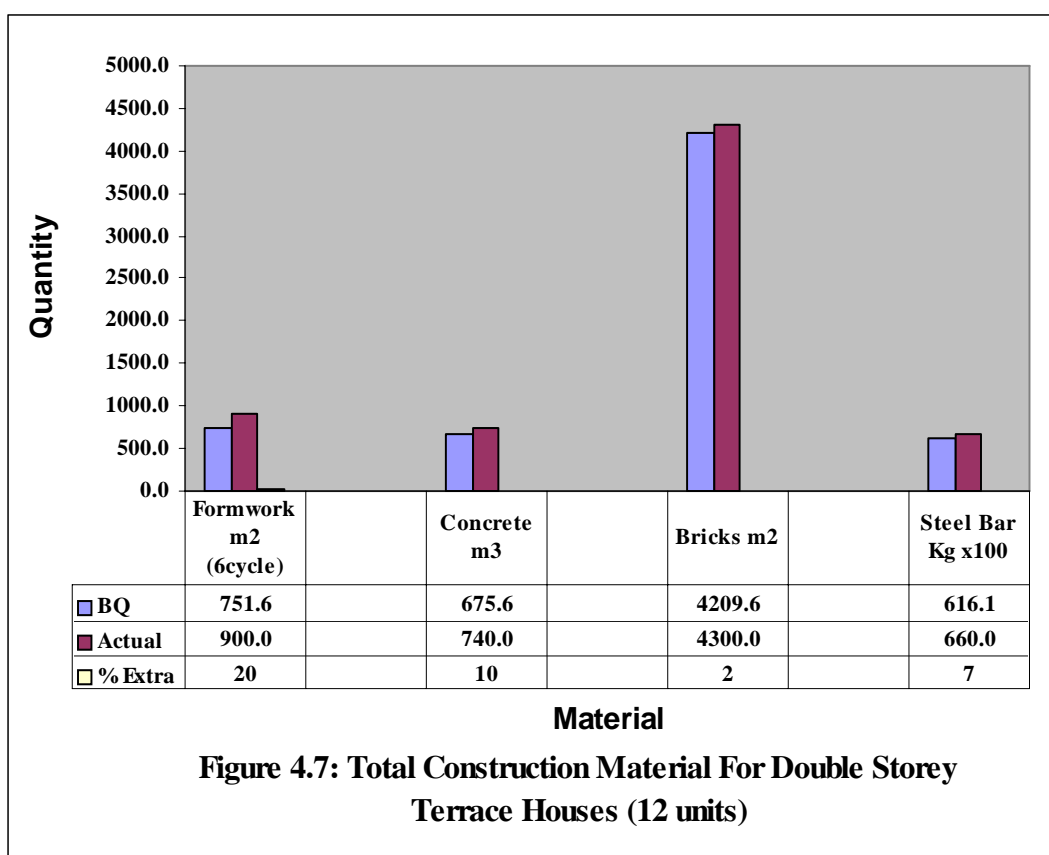
The remain of other types of construction waste have only some minor differences, which are bricks 0.54kg/sqft compared to 0.56kg/sqft, metals 0.07kg/sqft compared to 0.08kg/sqft, and cardboard 0.08kg/sqft compared to 0.1kg/sqft for semi-detached and terrace houses respectively.

### 4.3 Construction Material

The construction material that was taken into consideration in this study is wood that are used in formwork, concrete and steel bar for reinforcement concrete and bricks for all brickwalls. In the double storey semi-detached houses as show in Figure: 4.6, the quantities of formwork, concrete, bricks and steel bar required as per Bill of Quantity and calculation by drawing were 819.8m<sup>2</sup>, 779.4m<sup>3</sup>, 3885.7m<sup>2</sup> and 55,320kg respectively. But the actual quantity ordered to complete the project were 1,130.8m<sup>2</sup> for formwork, 840.0m<sup>3</sup> for concrete, 4000.0m<sup>2</sup> for bricks and 59,000kg for steel bars. There was an extra over on quantity of 38% for formwork, 8% for concrete, 3% for bricks and 7% for steel bars.

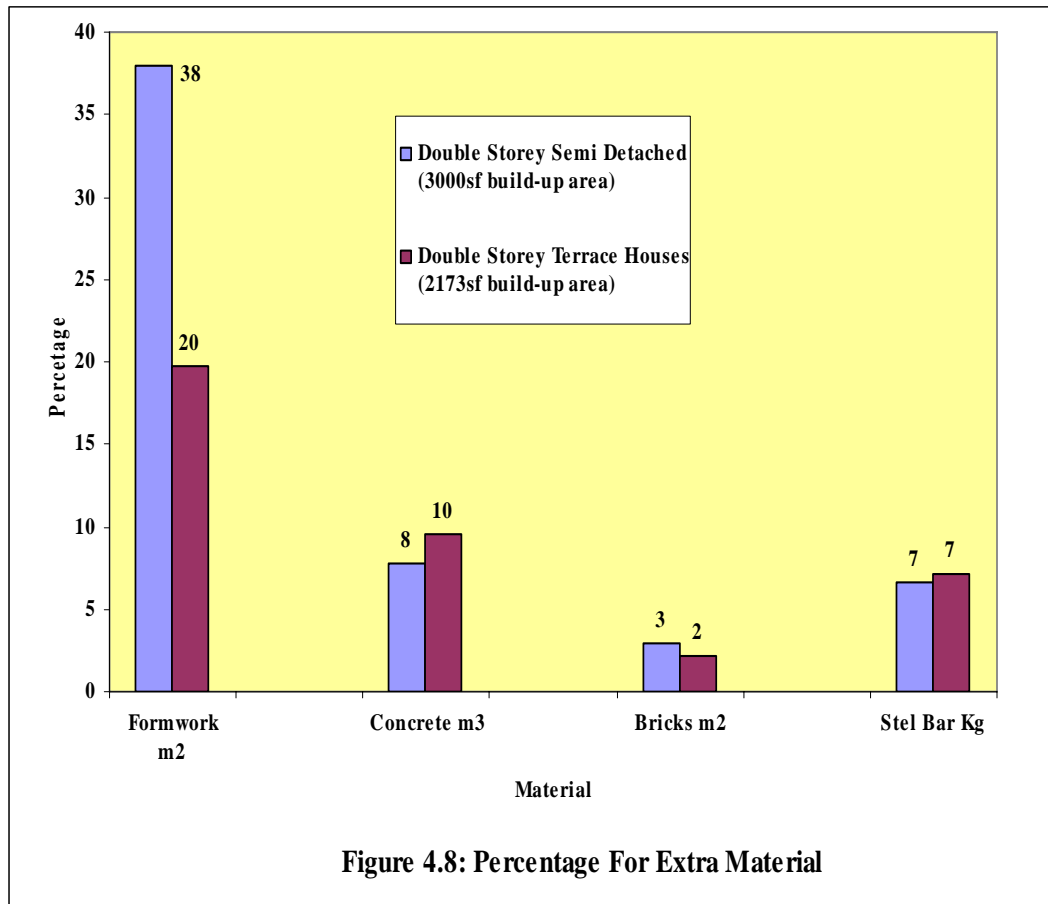


In the double storey terrace detached houses as show in Figure: 4.7, the quantities of formwork, concrete, bricks and steel bar required as per Bill of Quantity and calculation by drawing were 751.6m<sup>2</sup>, 675.6m<sup>3</sup>, 4209.6m<sup>2</sup> and 61610kg respectively. But the actual quantity ordered to complete the project were 900.0m<sup>2</sup> for formwork, 740.0m<sup>3</sup> for concrete, 4300.0m<sup>2</sup> for bricks and 66,000kg for steel bars. There was an extra over on quantity of 20% for formwork, 10% for concrete, 2% for bricks and 7% for steel bars.



In comparisons of extra material needed between double storey semi-detached and double storey terrace houses, as shown in figure: 4.8, indicates that the largest variance is on formwork, 18%. Extra formwork are needed as the quantities in the bill of quantity includes the exact dimension on the structure, where else the actual ordered quantity covers on the wastages during fabrication and replace on the damaged

formwork during the construction sequence usage. In this case 6 cycles are being use for per set of formwork.



Formwork is damaged during concreting, installing and striking off from the casted structure. Frequent damage also occurred due to the inferior quality of plywood used. Due to the competitive price, recycle material is used in making the plywood and is not as durable as it used to be.

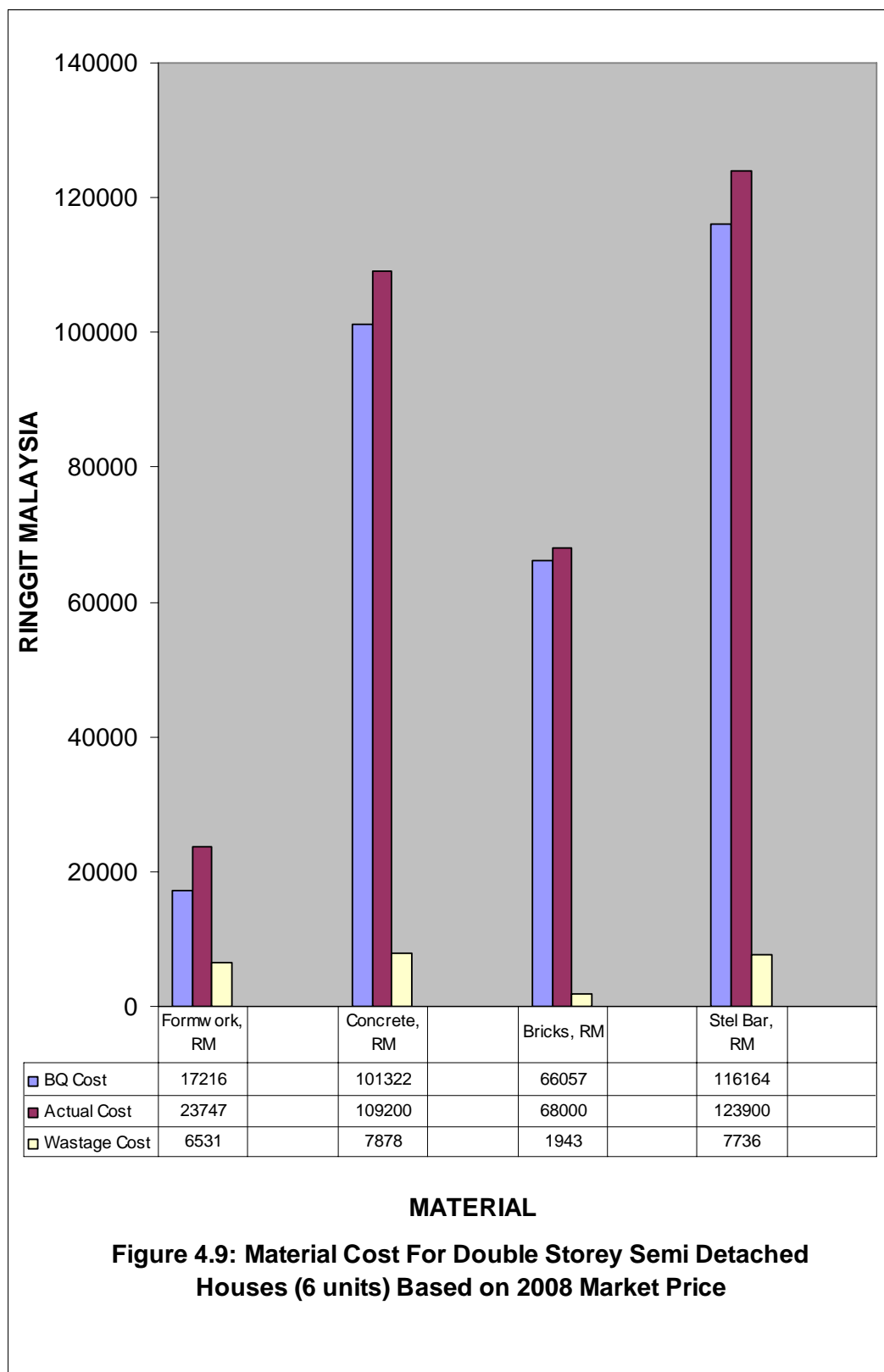
The extra 18% of formwork needed in double storey semi-detached house compared to the double terrace houses were due to the end quality of the luxury semi-detached. More formwork needs to be replaced due to wear and tear.

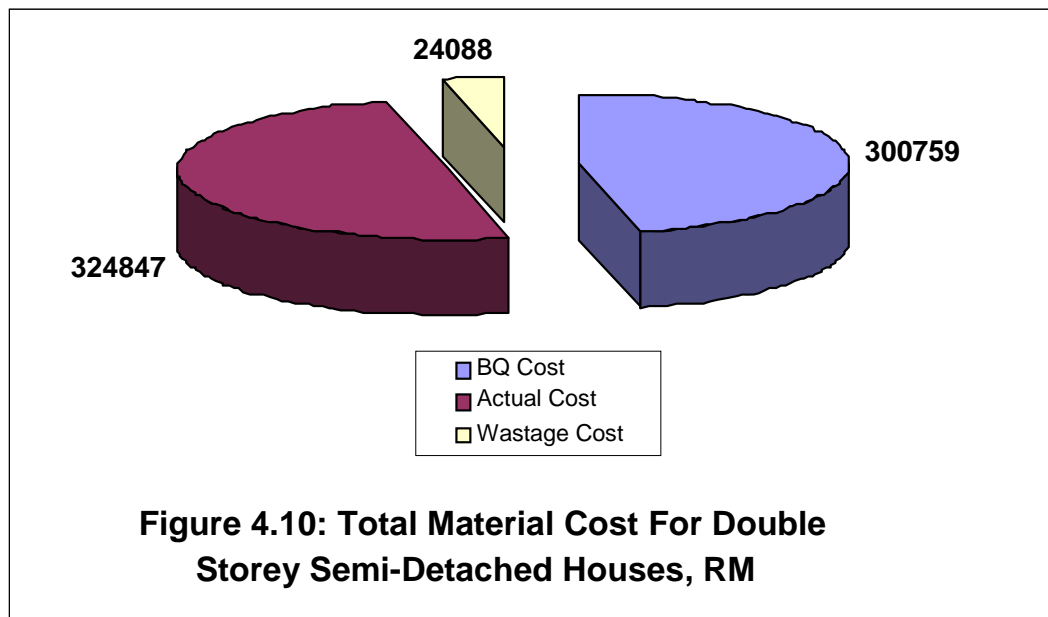
The extra needed in concrete was due to the wastage during concreting, concrete for slump and cube test sample. The variance additional 2% was for the double storey terrace houses even though the total quantities are lesser. This was due to the flat roof and minor roof beams in semi-detached compared to all roof beams in terrace houses. Small sizes of roof beams, lacked of supervision, the bulging of formwork and unskilled concretors contributed to the extra wastages.

Only minimal variance in bricks, 1% additional in the double storey semi-detached houses due to the extra wastage's on the stringent supervision on the quality brickwall needed. On steel bars, only slight differences between the types of houses and the extra quantity ordered compared to the bill of quantity was due to the wastage's on the cutting to size on the reinforcement and also pilferage on site.

#### **4.4 The Cost of Material Waste**

The overall cost of building construction depends much on the cost of building materials. The cost of construction materials plays an important role in the ability to deliver construction program. Once a project is defined and legislative approval given, tracking the costs of construction materials becomes an important variable in the delivery of a project within scope, schedule and budget. Tracking bid prices from construction contracts provides key data to monitor material cost trends. The cost of materials covers around 60% of the total cost of the concern trade. The total wastage cost for the four major material used, formwork, concrete, bricks and steel bar were calculated based on the year of 2008 market price of RM60.00 for a piece of plywood, RM130.00 for a cubic meter of grade 25 readymixed concrete, RM0.35 for a piece of common brick and RM2100.00 for a metric ton of steel bar.

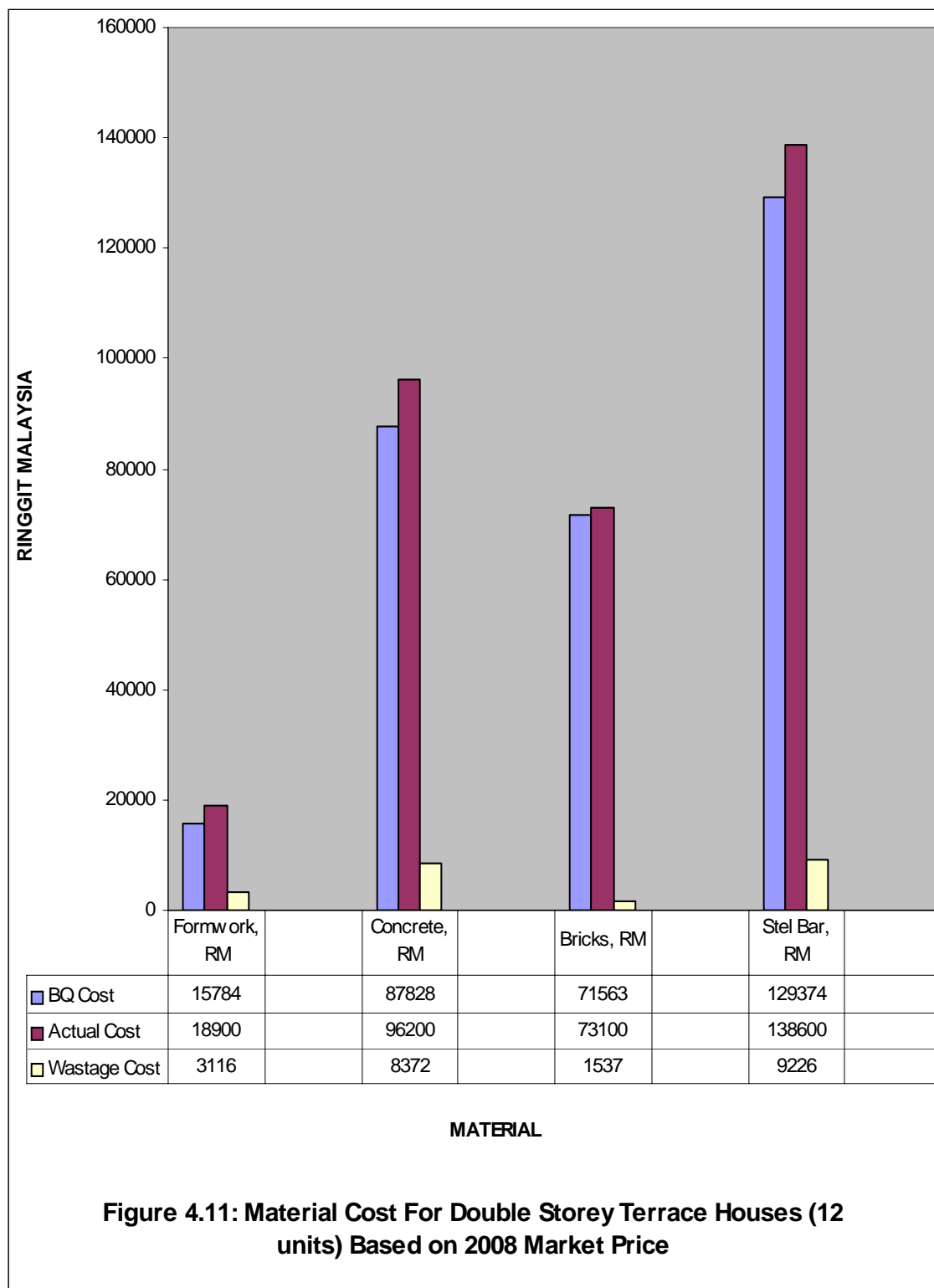


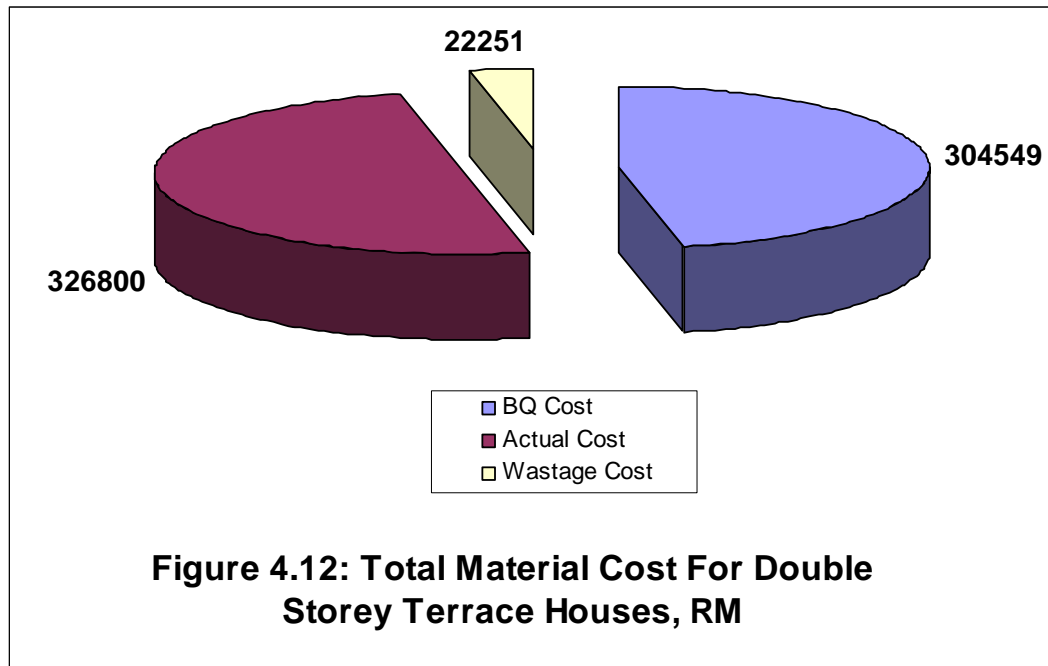


In this case study, the total wastage cost for the four major material used, formwork, concrete, bricks and steel bar were RM24,088.00 for double storey semi-detached house and RM22,251.00 for double storey terrace houses as shown in Figure 4.10 and Figure 4.12. The unit rate was based on the market price in year 2008

The major wastages in double storey semi-detached house were concrete RM7878.00, followed by steel bar RM7736.00, formwork RM6531.00, and bricks RM1943.00 as shown in Figure 4.9

For the double storey terrace houses, the major wstages were steel bar RM9226.00, followed by concrete RM8372.00, formwork RM3111.00 and bricks RM1537.00 as shown in Figure 4.11





For comparison purposes, the total percentage wastages on cost compare to BQ between double storey semi-detached and double storey terrace houses were 8% and 7.3% respectively. As a general guide, a wastage material cost of 7% to 8% should be allow for in the contract rate for luxury landed property construction, inorder to maintain the estimated profit margin. Any saving on material used during the construction stage will increase the budgeted profit.

A proper or a well managed of material at construction sites will minimize the wastages and reduces on the percentage of extras needed. Thus a lower percentage of addition to be allocated during the pricing on tender stage. This will eventually lower the contract price and become more competitive during the bidding.

## CHAPTER V

### DISCUSSION AND RECOMENDATION

In this study, the double storey terrace house which was sold for around RM160.00 per square feet of the build-up area were considered as a high end building for terrace houses. In the findings with a total built-up area of approximately of 2200 square feet on this type of houses, the percentage of wastages on the material purchase for the main structure for formwork, concrete, bricks and steel bar are 20%, 10%, 2% and 7% respectively based on the quantity needed. If it is a bill of quantity contract, where all the quantity are measured exactly according to drawing dimension, then the wastages percentages must be allocated in the rate in order to cover on the site wastages.

On semi-detached houses, which was sold around RM650.00 per square feet of the built-up area are considered as a luxury building. As in the finding, any total build up area of approximately 3000 square feet on this type of houses, the wastages percentage of material purchase for formwork, concrete, bricks and steel bars are 38%, 8%, 3% and 7% respectively. As in same case in terrace houses contract, if the additional quantity was not allowed in the bill of quantity, then it must be allow in the rate accordingly.

All these wastages must be considered during the tender or bidding stage. In order to have a competitive pricing, a minimal and lower cost are needed. Therefore, these wastages can be reduced by recycling the construction waste and stringent control of material at site during construction. As formwork is the most percentage of wastages needed, better or higher grade quality of plywood and timber should be purchased in order to maintain the estimated usage of formwork.

Normally the estimation percentage of wastages for a construction company, during the pre-tender stage was around 15% for formworks, 3% for bricks, 5% for concrete and 5% for steel bar. In this study, the findings in double storey semi-detached houses had an increase of 23% for formwork, increase of 3% for concrete, increase of 2% in steel bar and accurate estimation for bricks. In double storey terrace houses, it had an increase of 5% for formwork, increase of 5% for concrete, increase of 2% in steel bar and a saving of 1% in bricks. Overall the actual profit margin will decrease due to the purchase of additional material and also the disposal of extra construction wastes.

Precaution steps have to be considered to minimise the increase on the estimated wastages and if possible to reduce the estimation wastages percentage. If all the extras were due to workmanship, then stringent supervision should be implemented during the construction stage. If cheaper or inferior material are intended to be used, then a higher percentage of wastages should be allowed for during the estimation stage with greater amount of waste to dispose.

In the findings of construction waste, the total quantity variance from 2.63kg/sqft to 2.81kg/sqft for double storey semi-detached and double storey terrace houses. A waste plan must be developed to provide appropriate solution for managing the entire waste stream on site. This waste management is the practice of reducing the actual waste that goes to the landfill site. It will not only reduce the volume of waste disposal but

also the cost of management the waste stream. It might also generate some income by recycle or reuse that can eventually reduce some material pricing during bidding of contracts. There are three basic steps for construction waste management, that are reduce, reuse and recycle, which are commonly known as the three 'R's. Reduce is the precaution of waste arising and optimising material usage.



**Figure 5.1: Formwork major contribution in construction waste**

From the findings, the waste for woods variance between 25% from double storey terrace houses to 43% from double storey semi-detached houses. If a better quality of plywood are being use and precaution steps are taken during installing, striking and transferring of formwork, the percentage of damage can be reduce, hence the estimated cycle of usage can be achieve. This will reduce the purchase of extra material on formwork due to the minimum damaged replacement. This will eventually reduces this type of waste which is the major contributions as shown in Figure 5.1. If it is properly segreted, it can be reuse to the estimated cycle as shown in Figure 5.2 or

dispose it to those needed, such as brick factory which they needs it in their kiln operations.



**Figure 5.2: Timber can be reuse to the estimated cycle with proper storage**



**Figure 5.3: Timber pellet can be return to supplier**

Reuse is using existing material instead of throwing away. Reusing does not mean that it needs to be reused on the same construction site. Not only formwork to be reuse on the estimated cycle but timber pellets can also be return to supplier as shown in Figure5.3. This waste can also be either sold or giving it to those needed. The cost of disposing can be reduced with a smaller quantity of waste to dispose.

Another material that can be reuse at site is bricks and concrete as shown in Figure 5.4 and Figure 5.5 respectively. If properly segreted it can be use as hard material or as hardcore for ground or apron slab, road base or etc. In the findings these two wastes contributed to around 33% for double storey semi-detached houses and 36% for double storey terrace houses, out of the total construction waste generated. Even with the higher specification and quality finish for double storey semi-detached house, the total waste generated on this types are lesser compared to double storey teracce house. These was due to the less mistakes on the workdone and the better control during the construction.



**Figure 5.4: Brick that can be reuse as hardcore material**



**Figure 5.5: Concrete waste**

In the findings, the combine construction waste for steel and cardboard as shown in Figure 5.6 and Figure 5.7 consists of 6% and 7% of the total waste generated in semi-detached and terrace houses respectively. These types of waste can be recycle and have some resale value which will help reduce the cost of disposing the others types of constructions waste.



**Figure 5.6: Steel wire mesh that can be recycle**



**Figure 5.7: Cardboard that can be recycle**

The other waste consists of unuseable material as shown in Figure 5.8 and Figure 5.9 such as polystyrene, rubbish, plastic, and etc, which had to be totally dispose.



**Figure 5.8: Polysterene used in material packaging**



**Figure 5.9: Rubbish**

After consideration on the reuse and recycle of the construction waste, the quantity for disposal waste in semi-detached and terrace houses were 61% and 57% respectively on the total waste generated. These were 1.63kg/sqfeet of disposal waste for semi-detached and 1.62kg/sqfeet for terrace houses. In general from the study findings, the dispose of construction waste can be reduce from 40% to 50% if reuse and recycle are practice.

In the finding, the disposal option of construction waste at site is as following. The quantity of wood waste are 100% or totally disposed due to wear and tear after the usage of 6 cycle and it can't be reuse anymore. As for the concrete and bricks, it was totally or 100% reuse as mention earlier as a hard material for the temporary acces or permanaent road base.. The metal and cardboard was also 100% or totally recycle as this

waste has resale value in the market of recycle. The other or mixed waste was also totally disposed due to the mixture of unsuitable and unuseable material.

**Table 5.1: Construction Waste Disposal Cost**

<b>Type</b>	<b>Nos of Bins</b>	<b>Disposal Cost Based on 2008 price (RM)</b>	<b>Disposal Cost per square feet (RM)</b>
<b>Double Storeys Semi-Detached ( 6unitsx3000sqft)</b>	31	4650.00	0.26
<b>Double Storey Terrace Houses (12unitsx2173sqft)</b>	43	6450.00	0.25

In the study finding, as shown in Table 5.1 , the total dispose waste for semi-detached double storey and double storey terrace houses were 31 bins and 43 respectively based on the collected volume at site. The total disposal cost for the major material, formwork and other mixed waste were calculated based on the year 2008 market price of RM150.00 per bin. The disposal waste cost were RM4650.00 for the 6 units double storey semi-detached houses and RM6450 for the 12 units double storey terrace houses. The disposal cost per square feet of the built-up area for the double storey semi-detached and double storey terrace houses were RM0.26/sqft and RM0.25/sqft respectively. Only a variance of 1sen per square feet between the types of houses.

In any contract, the Contractor is responsible for the means, methods, techniques, sequences, and procedures of construction, which include waste disposal methods. However, the design team can contribute to waste reduction in several ways.

Observe Value Engineering principals. Perform multiple functions with one material rather than requiring multiple materials to perform one function. Design to optimize systems' and components' use. Avoid extraneous materials that do not contribute to function. Be efficient in area and volume. If less material is required by the design, less waste is generated at the jobsite.

Observe standard material and product dimensions. Locate features "on module or cut to sizes" to the extent possible to reduce cutting and special fitting, which creates scrap. Where possible, select construction systems that do not require temporary support, shoring, construction aids, or other materials that will be disposed of as debris during the project. Where possible, select materials that do not rely on adhesives, which require containers and create residue and packaging waste. Furthermore, adhesives inhibit salvage and recycling at the end of the component's or building's life. Where possible, reduce requirements for applied finishes, laminates, coatings, adhesives, and the associated scrap, packaging, and waste. Select materials with integral finishes. Where possible, avoid materials which are sensitive to damage, contamination, environmental exposure, or spoilage on-site, which increase the potential for jobsite waste.

There are a variety of ways a Contractor can divert construction waste or demolition debris at the jobsite. While protecting new materials is necessary, the contractor can direct their subcontractors and suppliers to reduce extraneous packing and packing. Purchase materials in bulk where possible. Avoid individual packaging for volume purchases. Use returnable containers and packing materials. Reuse non-returnable containers on the jobsite to the maximum extent possible. Develop one-

hundred-and-one-uses for plastic barrels, buckets, and tubs. Give away non-returnable containers. Contact local and community organizations (schools, youth groups, community service groups, others similar).

Use scrap in lieu of cutting full new materials. Direct subcontractors and trades to collect and keep scrap at cutting and fabricating locations. Collect paints and liquids from almost-empty containers, avoid disposing of useable materials simply because there is not enough in one container to finish a job. For materials that are heated, mixed, exposed to environmental conditions, or otherwise subject to spoilage, limit preparation of these materials to quantities which can be installed within their expiration times. Working in smaller batches will reduce the necessity to throw out expired or spoiled materials. Ensure volatile materials, and materials that degrade when exposed to heat, cold, or moisture are protected from spoilage and are not wasted.

Recycle damaged components, products, and materials, or disassemble them into their constituent materials for recycling. Establish a return or buy-back arrangement with suppliers. Alternatively, unused, or used but serviceable materials and products can be sold to architectural salvage or used materials retail outlets or donations to a non-profit outlet or organization. However, clean wood is frequently sold for boiler fuel, and some agencies do not allow incineration to be counted as diversion.

The Contractor may contract with individual recycling firms who deal in specific materials, in addition to a general waste hauler. This requires the Contractor, subcontractors and tradespersons to segregate waste, deposit it in the appropriate receptacles, and guard against contamination by other materials. The key to effective jobsite segregation is to place receptacles in the path of least resistance to the workforce, training the workforce to observe segregation practices, and policing the jobsite to prevent contamination. The construction process lends itself to on-site segregation. As

trades enter and leave the jobsite, each generates a relatively homogeneous waste stream, given the specific tasks and the materials with which they work. As the recyclable materials are segregated, the recycling firms generally offer a higher price for the material (if the contractor hauls), or a lower hauling rate (if the recycler hauls). Alternatively, the Contractor can contract with a waste hauler who provides receptacles for recyclable materials and debris, and hauls all materials as a one-stop service. While some contend site separation increases the cost of construction, efficient materials movement and site layout should minimize any increased effort.

The waste diversion potential in a demolition scenario is considerable. The building's construction type and project schedule are the two primary factors in determining what and how salvage, reuse, and/or recycling can be accomplished. Develop the project schedule to accommodate salvage, reuse, or recycling. The quality and quantity of materials salvaged is a direct function to the time available for salvage.

Materials management is another important element in project planning and control. Materials represent a major expense in construction, so minimizing procurement or purchase costs presents important opportunities for reducing costs. Poor materials management can also result in large and avoidable costs during construction. First, if materials are purchased early, capital may be tied up and interest charges incurred on the excess inventory of materials. Even worse, materials may deteriorate during storage or be stolen unless special care is taken. For example, cement or steel bar must often be stored in waterproof locations. Second, delays and extra expenses may be incurred if materials required for particular activities are not available. Accordingly, insuring a timely flow of material is an important concern of project managers.

Materials management is not just a concern during the monitoring stage in which construction is taking place. Decisions about material procurement may also be required

during the initial planning and scheduling stages. For example, activities can be inserted in the project schedule to represent purchasing of major items. The availability of materials may greatly influence the schedule in projects with a fast track or very tight time schedule and sufficient time for obtaining the necessary materials must be allowed. In some case, more expensive suppliers or shippers may be employed to save time.

Materials management is also a problem at the organization level if central purchasing and inventory control is used for standard items. In this case, the various projects undertaken by the organization would present requests to the central purchasing group. In turn, this group would maintain inventories of standard items to reduce the delay in providing material or to obtain lower costs due to bulk purchasing. This organizational materials management problem is analogous to inventory control in any organization facing continuing demand for particular items.

Materials ordering problems lend themselves particularly well to computer based systems to insure the consistency and completeness of the purchasing process. With a materials requirement system, much of the detailed record keeping is automated and project managers are alerted to purchasing requirements.

Recycling and reuse of materials have long been associated with wise construction practices. Experienced contractors are now reaping the economic advantages of Construction Waste Management.

Communities are also seeing the side benefits as listed below.

- Trim Costs.

Recycling, reusing, and salvaging construction waste can save money. Many of the contractors that have embraced Construction Waste Management have made changes to their operations and practices to take advantage of reduced waste

disposal costs and revenues derived from recycle, reuse and salvage materials. Utilizing reuse and salvage methods on site reduce the need for new materials, reduces materials that end up in the landfill, creates a cleaner and safer project site, and improves community relations.

- **Establish a Market Advantage.**  
A company's experience in waste prevention and recycling is a valuable marketing tool for bidding on projects in response to customer interest in Construction Waste Management. Efforts to prevent waste, to recycle, and to use recycled-content materials on a project can help the project team to maximize profit to the company.
- **Create Environmental Benefits.**  
Environmental benefits also result from recycling and waste prevention programs. In the long run, preventing waste reduces dependence on natural resources such as trees, oil, and minerals plus creates less pollution by reducing manufacturing and transportation related emissions. Reduction of the energy and water required to produce building supplies from virgin materials contributes to reduced greenhouse gasses related to the manufacturing and transportation of those materials. Ask suppliers to deliver supplies using sturdy, returnable pallets and containers. Have suppliers pick up pallets and empty containers. Require suppliers to take back or buy-back substandard, rejected, or unused items.
- **Help the Economy.**  
Recycling and reuse of construction waste can also help the economy through the creation of jobs related to salvaging and recycling of construction waste. New products create jobs through the manufacture of recycled content materials.
- **Assist Charitable Organization**  
Organizations such as Habitat for Humanity can use surplus building materials. Pick-up of materials at the project site can sometimes be arranged.

There are many methods used to reduce waste and increase profits through salvage, reuse, and the recycling of construction waste. In the construction industry, salvage and reuse are terms that are often used interchangeably. For the purpose, the term “reuse” denotes the materials that remain on the construction site to be used in their original form or converted to another use. Salvage, typically in its original form, is items that are removed from the site.

Planning a project with resource maximisation in mind rather than just waste minimisation. This will allow much more flexibility with on-site materials management. Use reclaiming and recycling businesses to minimise land fill and disposal cost rather than a waste disposal company. Waste companies make their money from transportation of waste. Consider product stewardship/responsibility approach with suppliers. Many are keen to participate in some way. Work with staff, contractors and suppliers to identify, modify and practice changes by setting targets and goals and by providing resources to educate / train. Allow participants to see and promote positive actions on site through the use of billboards, signs and displays. Develop a waste management ‘code of conduct’ for sites, staff and subcontractors. Understand and identify differences between sites, such as available storage, space to sort and other general materials handling issues.

Encourage use of the term "offcut" rather than waste. These materials are then referred to as metal offcuts, cardboard, plasterboard offcuts etc rather than waste. As soon as materials are referred to as waste they are perceived to have no value and treated accordingly. Promote a self-help bin internally as part of the materials management. Consider the salvage value of recovered materials in light of awarding a bonus. Consider rewards for good ideas. Initiate a trial with a local processor for plasterboard, cardboard and sand to be used in landscaping. Assess having contracted material handling on the project, implementing recovery and sorting for recycling. Consider using a person for

sorting and storing materials near bins. Identify waste/materials movement and management programs to trial in future stages of the construction project. Develop a system for monitoring materials entering and leaving the site, recording data such as specification, handling, storage, value and costs, so that pragmatic comparisons can be made. Identify additional 'best practice' activities in use on the site and review.

Use government authorities to raise the standards within the industry and sets the minimum standards. Much of the uncertainty can be overcome with education and promotion within the building industry. The development of a Code of Conduct for relevant trades and subcontractors, to enable awareness of the builders, Environment Protection Agency and industries expectations in regards to waste handling practices. Develop a draft 'Best Practices Manual for Construction Site Recycling. Hold forums/workshops for industry to participate as stakeholders in developing changes and expectations.

## **CHAPTER VI**

### **CONCLUSION**

Waste reduction practices are applicable to virtually any construction and demolition project scenario. The goal is to divert materials from landfill disposal to the greatest extent practical under the circumstances. There are two opinions about whether this is a realistic expectation under real world project conditions. One is that waste reduction costs money, and the other is that waste reduction saves money. As with any construction project, planning and project management will ultimately dictate whether waste reduction is accomplished within the established cost, schedule, and quality parameters. The disposal of construction waste is costing the industry more and more each year. Construction companies need to start identifying ways to reduce the amount of waste that is disposed of during the construction process. The most practical ways are to increase profits, become more resource efficient, minimize waste and disposal costs and finally to comply with new regulations.

The greatest uncertainty is usually the availability of salvage and recycling services and outlets, and any costs associated with handling these materials. Resources are available to help Owners, Architects, Engineers and Consultants Management professionals, and Contractors familiarize themselves with the salvage, reuse, and recycling industries and infrastructure. After all the options to prevent waste, salvage and reuse materials have been incorporated into the project, the next step is to recycle as

much of the remaining debris as possible. Recycling construction materials saves money by cutting disposal costs. It reduces waste going to the landfill, facilitates a cleaner and safer construction site, and improves community relations. Proven strategies for waste minimisation includes of reduction of resource consumption, reuse of components, recycling of materials, composting and energy generation from organic wastes. Each of these has been demonstrated as an effective means of reducing construction waste. The imposition of waste minimisation strategies from the top down however, may meet with entrenched resistance from those who see no reason for change and no benefit for themselves. Such a plan therefore should be supported by training and incentive programs which encompass the whole workforce. Safety and equity issues need to be given due consideration. It is generally regarded as helpful if all these matters are formalised in a written Waste Management Plan and the implementation process tends to be aided by clear definitions of the performance changes that are required. To ensure compliance with approved waste management plans some form of monitoring of waste performance needs to be introduced.

From the findings, it can be concluded that the total construction waste generated on building luxury landed building was 2.75kg/sqft. After consideration on the reuse and recycle of the construction waste, only the woods and the other mixed waste that needs to be totally dispose. These come to an average of 1.62kg/sqft for the total disposal, a reduction of 1.13kg/sqft and that is around 41% of the total generated construction waste. In general from the study findings, the dispose of construction waste can be reduce from 40% to 50% if reuse and recycle are practice. This is a critical point. If recycling costs more than disposal, then there will always be a very good reason not to recycle. But if recycling is cost-competitive or less expensive than disposal, then recycling should be considered as part of every job. As for the extra material purchase as wastages, the total percentage wastages on cost compare to BQ between double storey semi-detached and double storey terrace houses were 8% and 7.3% respectively. As a general guide, a wastage material cost of 7% to 8% should be allow for in the contract rate for luxury landed property construction, in order to maintain the estimated profit

margin. Any saving on material used during the construction stage will increase the budgeted profit. A proper or a well managed of material at construction sites will minimize the wastages and reduces on the percentage of extras needed. Thus a lower percentage of addition to be allocated during the pricing on tender stage. This will eventually lower the contract price and become more competitive during the bidding. As for the disposal cost on the waste, it can be generally conclude that it needs RM0.25/sqft for the construction of luxury landed properties.

**APPENDIX A**  
**DOUBLE STOREY SEMI-DETACHED HOUSES LAYOUT**





## APPENDIX C

## Recycling construction site waste materials makes cents

BY JULIE WALLEISA | GUEST COLUMNIST

Owners, general contractors and New Mexico businesses can all benefit from recycling the vast amount of waste that is generated by local construction activities. Most construction waste can be recycled, often at lower cost than landfilling the material.

The Associated General Contractors has stated that contractors can save money by recycling wood, concrete, and other common materials.

In addition to saving money on individual projects, construction recycling can divert a significant amount of waste from New Mexico landfills, and provide new local business opportunities.

The construction of a commercial building generates an average of 2 to 2.5 pounds of solid waste per square foot of building. Construction and demolition activities generate more than 130 million tons of waste nationally per year, and it is estimated that 30 to 40 percent of the landfill waste in New Mexico comes from the construction and demolition industry.

The largest volumes of construction waste typically come from concrete,



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wood, drywall, roofing, metal, brick, and plastic. Interior construction, such as tenant improvements, can produce significant amounts of gypsum board and finish materials.

Metal components such as structural steel, metal studs, sheet metal, flashing, and aluminum frames are easily recycled into new metal products. Recycling companies in and around Albuquerque accept virtually every type of metal, and pay for some types.

Waste concrete can often be returned to the local supplier to be crushed and reused as aggregate, road base, fill or landscape material. Cardboard and paper packaging also can be easily recycled.

Thoughtful construction practices can minimize waste and encourage reuse of scraps, formwork boards and other materials on-site. Some construction materials can be donated as well.

Habitat for Humanity's local ReStore accepts cabinets, doors, electrical hardware and fixtures, pipe and fittings, plywood, lumber, trim, plumbing fixtures and roofing materials that meet their criteria.

While there are numerous recycling companies in New Mexico, many of them are stockpiling or processing waste to be transported to other states, where it is recycled into new products. Having local end-uses for waste materials makes recycling easier, by providing a place to send materials and minimizing transpor-

tation.

Before their Albuquerque-based plants closed, companies such as Ponderosa Products and Rastra provided local markets for waste wood and Styrofoam.

New Mexico is still home to some end-users, such as the Durango McKinley paper mill, which makes its products from 100 percent recycled corrugated cardboard.

Two recyclable materials that currently have a very limited local market are wood and gypsum scraps. Scrap lumber, sheathing, formwork, pallets, trees and other wood items can be recycled into mulch, bulking agents for composting, manufactured wood products, and wood fuel.

While some local landscaping companies will accept clean scrap wood for mulch or compost, attracting local manufacturers of composite wood products could generate a more vibrant local market for the large amount of wood waste that is generated.

Similarly, gypsum board can be ground up and used as a soil amendment, cement additive or to manufacture new drywall products. However, there is little local demand for recycled gypsum due to the abundant sources of high-quality, locally mined natural gypsum.

In addition to companies that can recycle locally-generated materials, construction recycling provides a market for

companies that accept, haul and separate construction waste for distribution to end-users. This service allows contractors to mix recyclable materials on-site in a single container, saving space and time, but it is not currently available locally.

Local construction projects that are following Leadership in Energy and Environmental Design (LEED), or other green building, standards have been able to recycle 50 to 80 percent of the waste generated on-site, diverting thousands of tons of waste from local landfills.

Hopefully, as more New Mexico owners and contractors decide to recycle construction waste, the local market will continue to evolve to provide efficient recycling services and take advantage of recovered materials.

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The New Mexico Business Weekly welcomes columns from industry experts. These pieces can provide business advice, updates and insights on laws or regulations, new trends in an industry, or information on new technologies or products. Contact Maqum Kamerick, [makamerick@bizjournals.com](mailto:makamerick@bizjournals.com) or 348-8323, for more information.

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