# ANALYZE OF THE DIFFERENCE OF WASTAGE LEVEL BETWEEN RESIDENTIAL AND COMMERCIAL BUILDING USING PREFABRICATION METHOD

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# ANALYZE OF THE DIFFERENCE OF WASTAGE LEVEL BETWEEN RESIDENTIAL AND COMMERCIAL BUILDING USING PREFABRICATION METHOD

MIMI SYAFIZAH BINTI YUSOF

A Thesis submitted in partial fulfillment of the
requirements for the award of the degree of
Bachelor of Civil Engineering

Faculty of Civil Engineering & Earth Resources
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NOVEMBER 2009

I declare that this thesis entitles “*ANALYZE OF THE DIFFERENCE OF WASTAGE LEVEL BETWEEN RESIDENTIAL AND COMMERCIAL BUILDING USING PREFABRICATION METHOD”* is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree

Signature : …………………………..
Name : Mimi Syafizah Binti Yusof
Date :

To my beloved family;

*En Yusof Bin Said*

*Puan Rokiah Binti said*

*Mimi Azura Binti Yusof*

*Mimi Shahirah Binti Yusof*

*Mimi Syuhaidah Binti Yusof*

*Mimi Farhana Binti Yusof*

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## ABSTRACT

The construction industry consumes huge amounts of natural resources. The current implementation of prefabrication seems unable to provide satisfactory result to the construction industry. This paper provides partly an initial study, to identify types of construction solid waste on site, to identify the causes of construction waste and to examine the wastage level in adopting prefabrication in construction activities between two (2) types of building which are residential and commercial building. Generation of construction wastes constitutes a major impact to the environment. The awareness among contractors and builders regarding waste minimization is still low although various researchers have proved that environment of problems are getting more critical. Construction cost and technology are the important parameters that determine the material wastage. The data were obtained from 16 and 14 respondents on residential and commercial respectively through questionnaires that have been distributed at Selangor, Kuala Lumpur and Pahang area. All the data have been analyzed using average index. Site observation has been carried out to get additional information. All of the respondents are site engineers, contractors and manufacturers of Industrialized Building System. Average Index method will be used to analyze the data obtained. As a conclusion, types of construction waste such as concrete and timber, causes of construction waste such as careless at design stage and lack of communication between leader and worker and the difference of wastage level between residential and commercial building using fabrication method are established. In commercial building, the most average wastage is timber with value of 8.21. In residential building, the most average wastage in residential is concrete with the value of 11.4. It has been found out that the wastage level in commercial building is lower than residential building.

## ABSTRAK

Industri pembinaan merupakan sebuah industri yang menggunakan sumber alam dalam jumlah yang besar. Pada masa ini, pembabitan dalam kaedah pasang siap menunjukkan hasil yang tidak memuaskan dalam industri pembinaan. Tujuan kajian ini dilakukan adalah untuk menyelidik jenis – jenis bahan pembaziran di tapak bina, mengkaji sebab-sebab berlakunya pembaziran ditapak bina dan menyelidik tahap pembaziran di dalam kerja pasang siap antara bangunan perumahan dan bangunan komersial. Bahan pembaziran yang terhasil di tapak bina telah memberi kesan buruk kepada alam sekitar. Kesedaran kontraktor dan Pembina terhadap kepentingan pengurusan bahan binaan masih rendah walaupun pelbagai penyelidikan telah membuktikan bahawa masalah alam sekitar menjadi semakin kritikal. Dua (2) parameter penting yang menentukan tahap pembaziran adalah kos pembinaan dan penggunaan teknologi. Penyelidikan ini diadakan untuk mengenalpasti jenis-jenis bahan pembaziran dan kadar pembaziran bahan di antara kawasan perumahan dan kawasan komersial. Kajian telah di lakukan di kawasan Selangor, Kuala Lumpur dan Pahang. 16 responden dari kawasan perumahan dan 14 responden dari kawasan komersial telah memberi maklum balas terhadap borang soal-selidik yang telah diedarkan. Semua data yang diperolehi telah dianalisis menggunakan indeks purata. Maklumat data telah dikumpul dan lawatan tapak telah diadakan untuk mendapatkan maklumat lanjut dari jurutera dan kontraktor yang berpengalaman. Kesimpulannya, jenis-jenis sisa/buangan pepejal di tapak bina seperti konkrit dan kayu , faktor-faktor pembaziran bahan di tapak pembinaan seperti kesalahan ketika mengira bahan – bahan dan kurangnya kerjasama antara ketua dan pekerja, dan perbezaan pembaziran bahan di antara kawasan perumahan dan kawasan komersial telah di ketahui.

Hasil kajian mendapati bahawa kadar pembaziran bahan di kawasan perumahan adalah lebih tinggi berbanding kawasan komersial.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Construction waste can be considered as one of the main factors that can give serious impact to the environment. High demands of the infrastructure projects implementation especially in the commercial buildings and residential building becomes the main reason that causes construction wastage. Therefore, construction waste management indeed is a big and important issue that should be emphasized in Malaysia construction industry.

Production of the construction waste in a big quantity, with different composition is one of the main factors that contribute to a serious problem because the waste disposal will give bad effect to the environment.

For sustainable development and in order to conserve landfill capacity, there is an urgent need for the industry to adopt certain new construction methods or technologies, which can reduce waste effectively (EPD, 2003). Recently, the use of environmental friendly construction methods has been encouraged, such as using a large panel system, applying prefabrication components and reducing the application of wet trade (Ho 2001).

Prefabrication method in construction is not a new construction technology in global context but its application is still not common in Malaysia's building construction industry because of many factors. One of the factors is because Malaysia's contractors still choose the conventional technology in Malaysia building industry because the cost of this method is lower than other methods, even though it takes more time and producing more construction waste. Nowadays, the Malaysian construction industry is undergoing to transitional change from an industry employing conventional technology to more systematic and mechanised system. The new mechanised system is known as IBS (industrialized building system) or prefabricates method.

Prefabrication method was defined as a fabricated home one having walls, partitions, floors, ceiling and roof composed of sections of panels varying in size have been fabricate in a factory prior to erection on the building foundation. This is in contrast to the conventionally built home which is constructed piece by piece on the site (Kelly, 1950). Several benefits were identified of applying prefabrication such as better supervision on improving the quality of prefabricated products, reduce overall construction costs, shorten construction time an improved environmental performance for waste minimization (Tam et al, 2007).

For construction activities, it was found that, there are three (3) main factors that affect the characteristics of Construction &Demolition waste, which are structure type (e.g., residential, commercial, or industrial building, road, bridge), structure size (e.g., low-rise, high-rise) and activities being performed (Laeur, 1993). This study, gives an initial identification of the wastage level in application of prefabrication in comparison between residential and commercial building construction.

## 1.2 Problem Statement

Naturally, construction is not an environmental friendly activity. Existing research proves that construction is a major contributor to environmental pollution. For example, research (Recon 1996) reported that 44% of the 14 million tonnages of waste put into landfills in Australia each year is attributed to the construction industry. It shows that the environmental pollution which contributed by construction has been worsening as a result of rapid urban development. The major environmental impacts from construction activities are typically classified as air pollution, water pollution, waste pollution and noise pollution.

In Malaysia, 16,000 tonnes of solid waste produced in the country everyday. There are about 230 landfills in Malaysia and an estimated three (3) times as many illegal dumps. 80% of the landfills have an estimated remaining lifetime of only two (2) years (Agamuthu, 2003).

Basically, in construction project, contractor will give attention to make sure the construction will finish before the end date without any delay to earn profit. However, to those who are careless in managing waste or did not know how to choose a suitable method in handling waste can causes material wasting. Therefore, construction company or contractor should be able to identify a preferable and suitable method in handling waste to prevent a waste material.

Construction site waste is a major problem owing to the scarcity of land. Although figures published by the Ministry of the Environment put only “construction debris” in a separate category, and show that it is 5% of the total amount of waste, to encourage more responsible practices, disposal charges have been raised a number of times in the past decade. With the passing of the Environmental Public Health (Amendment) Act 1999, the legislation has been tightened, with stiffer penalties, to dissuade illegal dumping of wastes, an action for which construction companies are among the main culprits.

In most of the countries, little consideration has been paid on the control of generation of construction waste which this can be attributed to inexpensive or free of waste disposal and low environmental awareness of the construction industry. Labour cost is generally much more expensive than the building materials cost. (Wong and Yip, 2004) Therefore, contractors tend to allow considerable amount of material wastage on site, rather than put more human resources in managing the materials or educating the workers to minimize waste.

Disposal of public fill at public filling areas and mixed construction waste at sorting facilities or landfills has been the major approach for construction waste management. For sustainable development, we can no longer rely solely on reclamation to accept most of the inert construction waste. As such, the government is examining ways to reduce and also to promote the reuse and recycling of construction waste. Nevertheless, there will still be a substantial amount of materials that require disposal, either at public fill reception facilities or at landfills.

Today, we are running out of both reclamation sites and landfill space. With the current trend, our landfills will be full in early to mid-2010s, and public fill capacity can only last until the first half of 2009. Figure 1.1 shows in 2007, the mixed construction waste accounts for about 21% of the total waste intake at three (3) existing landfills. If there are insufficient public fill capacity and waste reduction measures being implemented, more public fill would probably be diverted to landfills and the landfill life will be further shortened.

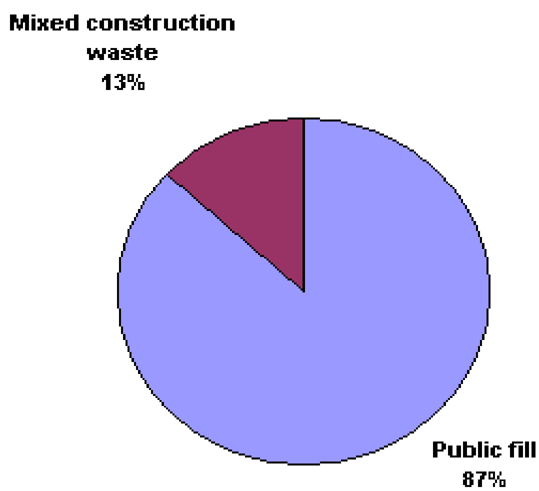



**Figure 1.1:** Construction Waste Generated in 2007 ( Source: www.epd.gov.hk)

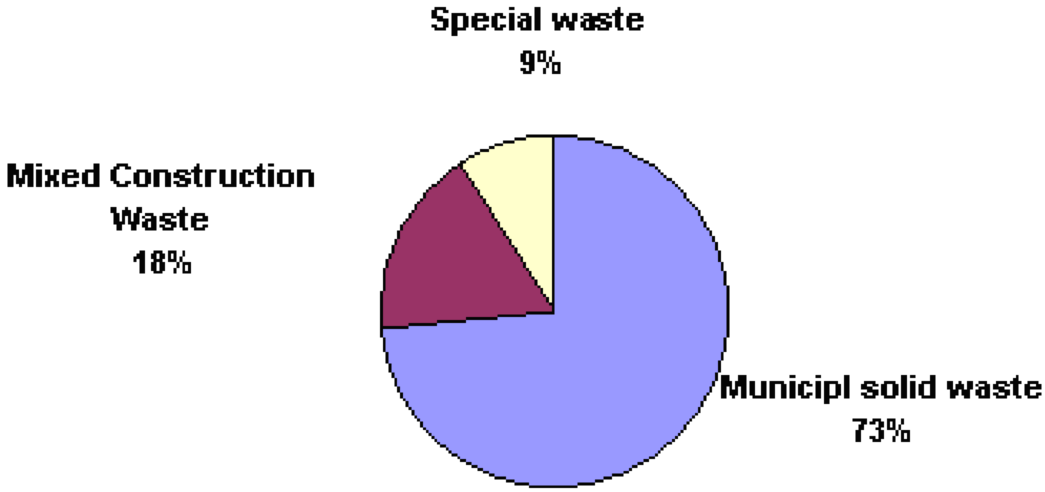



**Figure 1.2**: Composition of Waste Disposed Of at Landfills in 2007 (Source: www.epd.gov.hk)

## 1.3 Objectives

The objectives of this study are as follow:

i) To identify types of construction solid waste on site

ii) To identify the causes of construction waste

iii) To analyze the difference of wastage level between residential and commercial building using fabrication method.

## 1.4 Scope of Study

The area of this study is focusing on the construction companies located in Kuala Lumpur and Selangor. In this study, list of targeted survey respondents is randomly selected from the Construction Industry Development Board (CIDB). This study is focused on the wastage level and waste index in adopting prefabrication in construction activities between two (2) types of building which are residential and commercial building.

A set of questionnaire have been prepared and have been mailed to several construction companies in Kuala Lumpur and Selangor. Interviews have been carried out to survey on the extent of the residential and commercial building that used fabrication method.

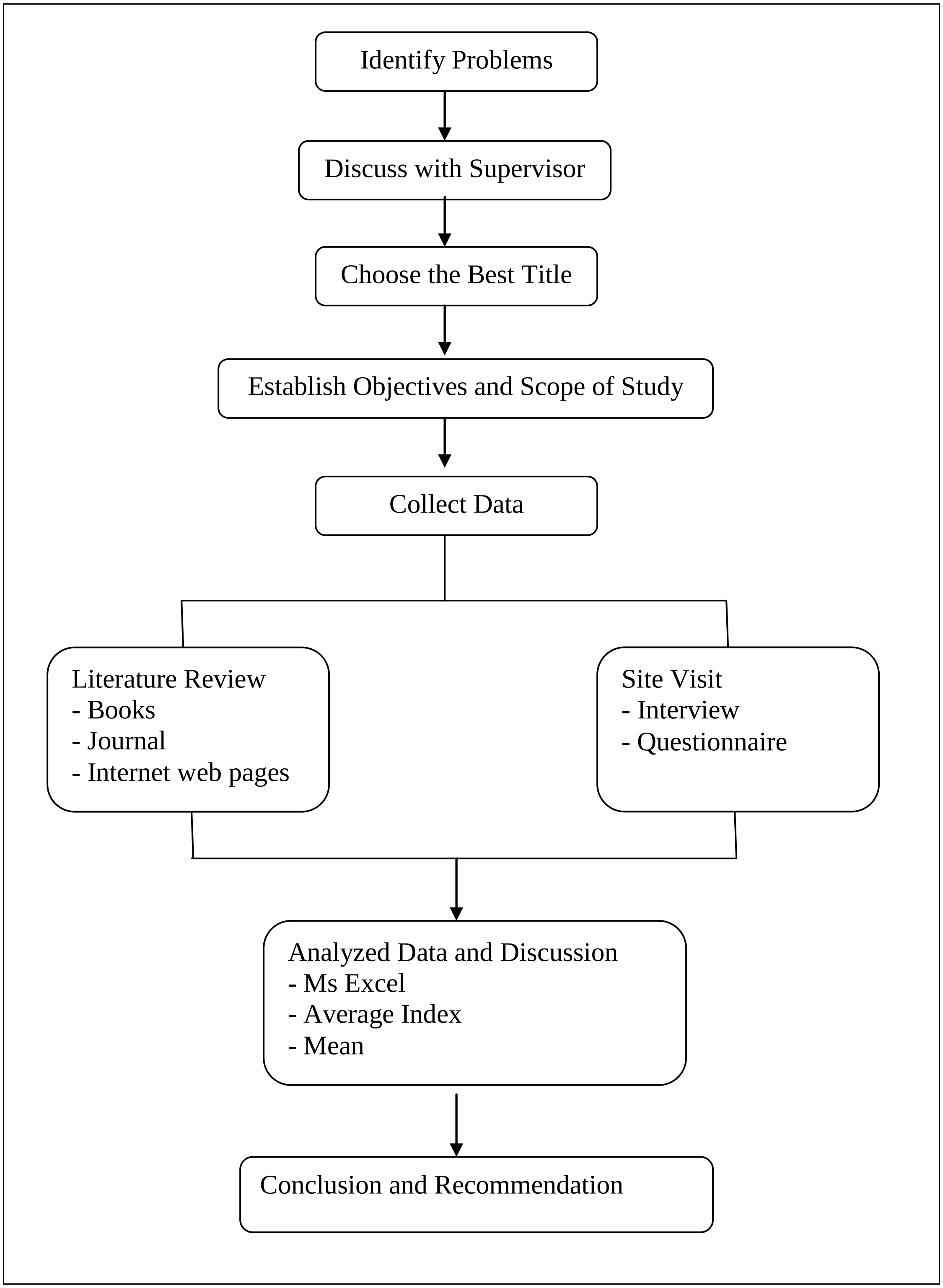
## 1.5 Significance of Study

The importance of this study is raising the awareness of contractors, engineers and site workers regarding to waste management, which the effectiveness of implementation of waste management into construction project will lead to reduction of construction cost and bad effects towards environment. Besides, it is very important for contractors to adopt new and effective construction method by considering the advantages and disadvantages of that method.

A research which conducted by Lingard et.al.(2000) had proved that one of the construction firm in Australia has been able to reduce landfill space used by 43%. Meanwhile, the company enjoy a 55% cost saving and recycle 35% of waste generated. It shows that the reduction of construction waste not only yields significant benefit to the environment, but also reducing cost of construction. It is absolutely imperative for the construction industry to adopt ecologically sound planning and construction practices for the purpose of creating a healthy and sustainable built environment.

Prefabrication method is expected to change the current local construction industry scenario resulting in systematic mass production of construction materials. Moreover, it is an important alternative to reduce the dependency of foreign workers in construction industry. The dependency on labor not only causes the increasing outflow of Ringgit to foreign economics, but it also brings negative impact to the nation in social and cultural context. So, it is important for local player to be ready and to begin search for an alternative to the labor-based construction method.

## 1.6 Research methodology



# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

Construction waste is defined as the by-product generated and removed from construction, demolition and renovation workplaces or sites of building and engineering structure Cheung et.al(1993). According to Hore et.al (1997), for every 100 houses built there is enough waste material to build another 10 houses. Similarly Akinpelu (2007) is of the opinion that on most capital projects resources from which wastes are generated account for more than 60% of their production costs.

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

There are two (2) main types of building waste, structural waste and finishing waste. Structural waste is generated during the course of construction. Finishing waste is generated during the finishing stage of a building. Construction wastes are disposed of at landfills and public filling areas.

Construction waste management is an important environmental issue. The huge volume and various compositions of construction waste have made its disposal a serious problem because it leads to environmental impacts such as landfill space and resource depletion. Greater concerns must be given to construction waste generation and management to reduce its burden to the environment. Moreover, waste measurement plays an important role in the management of production systems since it is an effective way to assess their performance, allowing areas of potential improvement to be pointed out.

Most construction waste goes into landfills, thereby increasing the burden on landfill loading and operation; a significant portion of the remaining are dumped indiscriminately, particularly in third world countries. Waste from sources such as solvents or chemically treated wood can results in soil and water pollution. Landfills are costly and scarce and dumps are unsightly and are continuing sources of environmental hazards. This has led researchers to suggest reduced construction waste generation as a way of ameliorating these problems.

In recent years, the construction industry has depleted natural resources of nations and invariably has led to environmental degradation. Due to lack of environmental awareness, contractors have caused irreversible damage to the environment by disposing of waste materials blatantly. Besides, this construction activities has caused air and water sources to be polluted and all of these could lead to health complications. It is obvious that effective construction waste management must be properly implemented in a bid to stem these negative consequences (Cobra, 2008).

Generally construction activities which lead to produce wastage can be grouped into off-site and on-site operational activities. Off-site activities include mining and manufacturing of materials and components, transportation of materials and components, land acquisition, and project design. While the on-site construction activities relate to construction of a physical facility.

Both on-site and off-site activities can result in pollutions under the categories of ecology, landscape, traffic, water, energy, limber consumption, noise, dust, sewage and health and safety hazards. In order to manage such a huge quantity of construction waste, some countries has adopted some strategies of wastage deposition.

Prefabrication techniques are used in the construction of apartment blocks and housing developments with repeated housing units. The quality of prefabricated housing units had increased to the point that they may not be distinguishable from traditionally-built units to those that live in them. The technique is also used in office blocks, warehouses and factory buildings. Prefabricated steel and glass sections are widely used for the exterior of large buildings.

An example from house-building illustrates the process of prefabrication. The conventional method of building a house is to transport bricks, timber, cement, sand, steel and construction aggregate, examples to the site, and to construct the house on site from these materials. In prefabricated construction, only the foundations are constructed in this way, while sections of walls, floors and roof are prefabricated (assembled) in a factory (possibly with window and door frames included), transported to the site, lifted into place by a crane and bolted together.

Prefabrication saves engineering time on the construction site in civil engineering projects. This can be vital to the success of projects such as bridges and avalanche galleries, where weather conditions may only allow brief periods of construction. Additionally, small, commonly-used structures such as concrete pylons are in most cases prefabricated.

## 2.2 Environmental Management Issue

Nowadays, Malaysia is running out of space to dispose of the urban waste generated daily by wasteful consumption. The number of landfills in Malaysia is not enough. According to Housing and Local Government Minister, Datuk Seri Ong Ka Ting, 80% of the country’s landfills will be full in two (2) years. In fact, landfills themselves cause many serious environmental problems for us and for future generations. Not many realize it, but each Malaysian throws away an average 0.8 kg of waste daily. Malaysia is among the countries that have a high rate of waste generation.

Our country generates around 15,000 tons of waste everyday. It is only a matter of time before we ran out of space to dispose of them. If we put them all together, we have enough waste to fill up the KL Twin Towers in just 9.5 days. In fact, the amount of waste is expected to increase by 2% every year, depending on our population, economic activity and waste disposal methods.

## 2.3 Prefabrication

A fabricated home is one having walls, partitions, floors, ceiling and roof composed of sections of panels varying in size which have been fabricated in a factory prior to erection on the building foundation. This is in contrast to the conventionally built home which is constructed piece by piece on the site ( Kelly, 1950).

The theory behind the method is that time and cost is saved if similar construction tasks can be grouped and assembly line techniques can be employed in prefabrication at a location where skilled labour is available, while congestion at the assembly site, which wastes time, can be reduced. The method finds application particularly where the structure is composed of repeating units or forms, or where multiple copies of the same basic structure are being constructed.

Prefabrication avoids the need to transport so many skilled workers to the construction site, and other restricting conditions such as a lack of power, lack of water, exposure to harsh weather or a hazardous environment are avoided. Against these advantages must be weighed the cost of transporting prefabricated sections and lifting them into position as they will usually be larger, more fragile and more difficult to handle than the materials and components of which they are made.

### 2.3.1 Advantages and Disadvantages of Using Prefabrication Method

There are some advantages of prefabrication which are self-supporting ready-made components are used, so the need for formwork, shuttering and scaffolding is greatly reduced. Construction time is reduced and buildings are completed sooner, allowing an earlier return of the capital invested. On-site construction and congestion is minimized. Besides that, quality control can be easier in a factory assembly line setting than a construction site setting.

Prefabrication can be located where skilled labour is more readily available and costs of labour, power, materials, space and overheads are lower. Other advantages of using prefabrication are time spent in bad weather or hazardous environments at the construction site is minimized. Less waste may be generated and in a factory setting it may be easier to recycle it back into the manufacturing process, for instance it is less costly to recycle scrap metal generated in a metal fabrication shop than on the construction site.

However, the prefabrication method also has their disadvantages such as must always be careful while handling the prefabricated components such as concrete panels and glass panel. Besides that, fully attention has to be paid to the strength and corrosion-resistance of the joining of prefabricated sections to avoid failure of the joint. Similarly, leaks can form at joints in prefabricated components. Transportation costs may be higher for voluminous prefabricated sections than for the materials of which they are made, which can often be packed more compactly and large prefabricated sections require heavy-duty cranes and precision measurement and handling to place in position

## 2.4 Residential Building

A residential area is a land use in which the predominant use is housing. Housing may vary significantly between, and through, residential areas. These include single family housing, multiple family housing such as apartments, duplexes, town homes (or similar configurations), condominiums or mobile homes. Zoning for residential use may permit some services or work opportunities or may totally exclude business and industry. It may permit high density land use or only permit low density uses. Residential zoning usually includes a smaller FAR (floor to area ratio) than business, commercial or industrial/manufacturing zoning (Wikipedia, 2009).

In certain residential areas, largely rural, quite large tracts of land may exist which have no services whatsoever. Because of a large distance must be traveled to access the nearest services, most journeys involve using a motor vehicle or some other form of transport. This need has resulted in residential land development usually existing or planned infrastructure such as rail and road. The pattern of development is usually set forth in the restrictive covenants contained in the deeds to the properties in the development, but may also result from or be reinforced by zoning (Wikipedia, 2009).

## 2.5 Commercial Building

A commercial building is a type of building that is used for commercial use. These can include office buildings, warehouses, or retail (i.e. convenience stores, 'big box' stores, shopping malls, etc.). In urban locations, a commercial building often combines functions, such as an office on levels 2-10, with retail on floor 1. All municipalities / cities / regions maintain strict regulations on commercial type zoning, and have the authority to designate any zoned area as such. A business must be located inside of an area zoned at least partially for commerce to operate a business in (and out of) a commercial building (Wikipedia, 2009).

## 2.6 Construction Material

### 2.6.1 Definition of Construction Material

"Construction material" means an article, material, or supply brought to the construction site by the Subcontractor or a lower-tier subcontractor for incorporation into the building or work. The term also includes an item brought to the site preassembled from articles, materials, or supplies such as aggregate, masonry, timber, steel, plastic, paper and others. (Fédération Internationale du Recyclage, 2003)

### 2.6.2 Masonry in Construction

Masonry is the building of structures from individual units laid in and bound together by mortar. The common materials of masonry construction are brick, stone, concrete block, grass block and tile. 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 of the units are laid in can strongly affect the quality of the overall masonry construction. Masonry is commonly used for 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", metal strips that are attached to the structural wall as well as the mortar joints of the brick veneer wall.

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 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).

### 2.6.3 Timber in Construction

Another major material used is timber board. The main causes of wastage are the natural deterioration resulted from usage and cutting waste. Among the projects surveyed, there is one (1) construction site bearing wastage of 20% in timber used for foundation works. Timber usually dumped after use to do formwork. Timber cannot resist termites and can easily broken. Therefore, it is not suitable for long-term usage. Old timber also usually ends up in the trash and cannot be recycled.

As a construction material, timber is strong, light, durable, flexible and easily worked. It has excellent insulating properties. In contrast to the substitutes for timber in structural and architectural uses such as brick, concrete, metals and plastics, timber can be produced and transported with little energy consumed and the products are renewable and usually biodegradable (Koch, 1991).

The decreasing timber supply from natural forests will be supplemented by timber from plantations and secondary or lesser-used species will be adopted more and more as construction materials. Non-traditional materials will also be used more extensively in the future.

Rubber wood looms is an important source for both household furniture and construction. The palm stem especially that of coconut, will also be used to 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 non-traditional 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 timber construction products themselves (Koch, 1991).

### 2.6.4 Steel

Steel reinforcement bars are also common materials used on construction site. The main cause of wastage is resulted from cutting. Damages during storage and rusting also form a major part of wastage. Pre-bending in the factory could reduce cutting waste. Traditionally, steel have certain characteristic physical properties: they are usually shiny (they have "lustre"), have a high density, are ductile and malleable, usually have a high melting point are usually hard, and conduct electricity and heat well. However, this is mainly because the low density, soft, low melting point metals happen to be reactive and we rarely encounter them in their elemental, metallic form.

### 2.6.5 Aggregate

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. Such substances as reactive chert, gypsum, iron sulfide, amorphous silica, and hydrated iron oxide are considered deleterious.

Fine aggregate is divided into two (2) categories which are natural sand and manufactured sand. Natural sand is fine aggregate resulting from glacial or water 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.

### 2.6.6 Plastic

Plastic waste is one of the components in municipal solid waste management. Plastics are predominantly employed in packaging, construction and consumer products. The first commercial plastics were developed over one hundred years ago. Now plastics have not only replaced many wood, leather, paper, metal, glass and natural fiber products in many applications, but also have facilitated the development of entirely new types of products.

The plastic fraction in municipal solid waste consists mainly of polyethylene (PE), polyethylene terephthalate (PET), polyvinyl chloride (PVC) and polypropylene (PP) and polystyrene (PS). Different types of plastics will perform differently in the environment, e.g. polyvinyl chloride (PVC) has caused concern because of their potential to cause environmental harms. Plastic products are durable, which although having functional benefits, can cause problems at the end of products' lives.

As plastics have found more markets, the amount of plastic produced becomes increases. This phenomenal growth was caused by the desirable properties of plastics and their adaptability to low-cost manufacturing techniques. This results in toxins existing in the water, air and food chain, bringing the people around the polluted area severe health problems. Recently, environmental groups are voicing serious concern about the possible damaging impact of plastics on the environment. Plastics end products and materials eventually contribute to the solid waste stream.

### 2.6.7 Paper

Paper is made from cellulose fibre, the source of which can be pulped wood, or a variety of other materials such as rags, cotton, grasses, sugar cane, straw, waste paper, or even elephant dung. There are different sources of waste fibre used as a source material for manufacturing recycled paper. Most paper waste is recycled.

The main types of paper in everyday use which can be recycled are office white paper, newspapers, magazines, telephone directories and pamphlets, cardboard, mixed or colored paper, computer print out paper.

There are also different grades of paper and board collected mainly from agricultural and industrial sources. Paper materials that cannot be recycled are limited for examples, paper food wrapping (as well as raw garbage), papers soiled during cleaning, cotton waste, paper cups, paper plates, paper milk cartons, carbon paper, heat sensitive paper, and paper with vinyl-coating.

## 2.7 Construction Waste

### 2.7.1 Definition of Construction Waste

"*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 metal and plastics, if the metal or plastics are a part of the materials of construction or empty containers for such materials.

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 (Daniel H. Tuttle, 1997).

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 paint, solvent, 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 nonhazardous 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).)

### 2.7.2 Types and Quantities of Construction Waste

Figure 2.1 and Figure 2.2 show the types and quantity of construction waste.

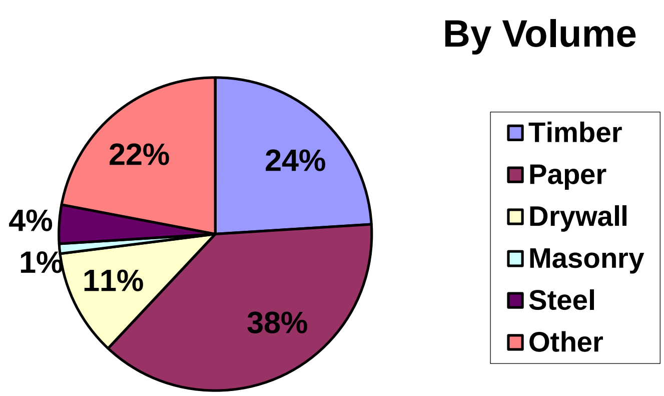



**Figure 2.1**: Types and Quantities of Construction Waste by Volume

(Source: oikos.com/library/waste/types)

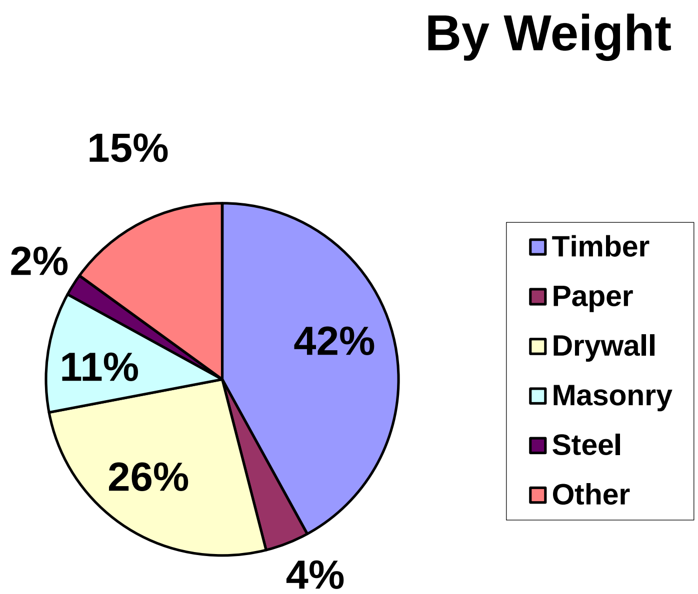



**Figure 2.2**: Types and Quantities of Construction Waste by Weight
(Source: oikos.com/library/waste/types)

There are some important generalizations about residential construction waste which are by weight or volume, wood, drywall and cardboard make up between 60 and 80 percent of jobsite waste. Vinyl and metals are generated in small quantities, but have good recycling value. Cardboard waste is increasing on most jobsites as more components, such as windews, appliances, cabinets and siding, are shipped to builders over long distances. Most wood waste is "clean" unpainted, untreated and recyclable.

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

### 2.7.3 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.

There are three (3) simple actions that can be considered in managing waste which are:

2.7.3(a) 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.

2.7.3 (b) Following the three (3) R's :

The order of the three (3) R's is reduce, reuse, and recycle. With waste reduction, particularly framing waste, we can save twice a once with a reduced take-off list and again when pay for less disposal. Three (3) 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 taxdeductible donation.

2.7.3(c) 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.

### 2.7.4 Importance of Construction Waste Management

#### 2.7.4.1 Cost

Eventhough 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(5) percent of the profit on a home. Waste reduction can reduce material purchases; recycling can finally reduce total disposal costs.

#### 2.7.4.2 Efficiency

One has to pay twice for materials wasted on jobs sites, once for the original purchase and again when the usable material is hauled off for disposal. It is not difficult to find useful building materials "hidden" within the six-foot-high sides of site dumpsters.

#### 2.7.4.3 Resource Conservation

Roughly 80 percent (80%) of a home builder's waste stream is recyclable. Home builders can do their part to conserve natural resources and landfill space by looking at their waste stream and seeing resources instead of refuse.

**2.7.4.4 Liability**

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.

**2.7.4.5 Marketing**

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.

**2.7.5 Causes of Wastes**

Throughout the life cycle of a construction project, there are number of factors leading to the production of wastes. The causes of waste that have been identified are design, procurement, materials handling, construction/renovation and demolition. (Graham and Smither, 1996).

#### 2.7.5.1 Design

Carelessness at the design stage leads to excessive cutting wastes and shortages of materials on site. Architectural design and rare standard formwork can affect the constructability and assemblies of a building. Plan and detail errors as a result of time constraint can cause variations that require input of additional materials.

Rounce (1998) pointed out that the major construction waste sources are at design changes, the variability in numbers of drawings and the variability in the level of design details. Most often the designers pay less attention to dimensional coordination of products and standard sizes of material products available on the market. The client and designer made changes to the design while construction is in progress caused the previous work done has to be aborted.

Some designers are not well experienced in adopting the right method and sequence of construction and unfamiliar with alternative products will cause the material wastage due to improper planning. Complexity of detailing and lack of information in the drawing are usually confusing and wrongly interpreted by the contractors. Incomplete contract documents at commencement of project will also cause the material wastage.

### 2.7.5.2 Procurement

Material wastage during procurement is related to ordering error, over ordering, under ordering, supplier’s error and so on. Faults in taking-off, unfinished detailing and small quantity of materials required in renovation work are the main cause of over-ordering. Lack of care during transportation can result in materials damage. Some occasions where the contract documentation was not complete when works orders were executed, therefore it had made accurate ordering of materials and scheduling delivery difficult, resulting in the purchased products do not comply with specification. Unclear records of purchase, delivery, usage and payment lead to disordered ledger and makes waste control pointless

### 2.7.5.3 Material Handling

Lack of confined space always causes storage problem for materials. Consequently, waste results from bad stacking, rusting of steel, damaging and aging of formwork. The major cause of material wastage due to improper handling is the attitude of project team and labourers. The building components were damaged during delivery because of insufficient protection during loading and unloading. Inappropriate storage leads to the damage or deterioration of materials.

For example, the aggregate is laid direct on the ground especially when the ground is soft, the aggregate will eventually descend into the ground. The steel reinforcement is laid direct on the wet ground and finally causes the corrosion of the steel. Sometimes, the operators simply use whatever materials which are close to working place.

#### 2.7.5.4 Construction/Renovation

The construction process accounts for the physical generation of waste materials. Poor supervision by the main contractors over the labour and sub-contractors can result in human error that can also result in waste generation. Over-mixing and materials surplus frequently occurs for wet trades like concreting and blockwall. Multifunction of equipment and its use by the labourer could cause damage to materials.

#### 2.7.5.5 Demolition Works

This is contrasted with deconstruction which is the pulling down of building. It is done when the structure is no longer safe to be used by the public. The tipping of materials from demolition creates a large proportion of wastes.

#### 2.7.5.6 Cultural

Attitudes will differ across different organizations according to their culture and waste management policies and across the various occupational groups in the construction industry. Research conducted by Malim (1997) indicates that attitudes are shaped over time and change according to a variety of factors, the most powerful of which is an individual's personal experiences of a situation or object.

For example, if an individual has worked on a project where waste management practices were highly successful, then his or her attitude is likely to be positives. The unpredictability of self interest and a fear of change hinder the culture of the industry from shifting.

### 2.7.5.7 Level of Knowledge

Occupational cultures of workers are shaped largely by common educational background, which determine their access to information about a particular issue. Environmental consciousness has traditionally not been taught as a part of educational programmes for professions in the construction industry. Chan (1998) viewed that the lack of education about the environment has been counteracted by the powerful modern influence of mass media.

### 2.7.5.8 Lack of Communication Leader and Worker

In construction project, individual responsibilities are poorly defined especially responsibility towards waste reduction and perceived as irrelevant to operatives, attributed to inadequately communications. Besides, work experience served as the primary source of knowledge about waste reduction activities, making it difficult for operatives to archive what was required by some managers. A change in the attitude of construction's workers including contractor and designer may be more important than changes in building technology, with regards to construction waste management (Wong and Yip, 2004).

In order to focus on worker's change efforts more effectively, the understanding of the influences of various factors upon people's attitudes and behavior is very important. The site foreman, leading hands, tradesman, and laborers make up the bulk of the site workforce and have the most direct physical contact with the materials being waste. They are important because they occupy a critical position in the construction waste generation chain, their attitudes have a direct and immediate impact upon its efficiency (Lingard et.al, 2000).

### 2.7.6 Waste Prevention

According to Brouwers and Bossink (1996), prevention of the generation of construction waste can be considered as an issue that focuses on the danger of depletion of materials used in the construction industry, and the danger of contamination of the ground because it is still common practice to transport often contaminated construction waste to landfills. The waste is generated by different individuals taking different roles in the building projects. In order to reduce waste generation in construction, certain waste prevention methods need to be adopted including measures at the planning stage and during construction stage.

#### 2.7.6.1 Recommendation to Reduce Building Waste

The subject of green architecture is all in vogue these days. Published material abounds on different ways to reduce waste produced by building construction and building use. Sometimes going over the top with suggestions that are difficult and unpractical.

The following is an extract from those recommendations (Tchobanoglous, 1993):

i. Ask the architect for building designs that use standard material sizes. This will reduce wastage from off cuts.
ii. Reduce the need for emergency material runs by planning ahead.
iii. Reduce packaging waste by consulting with suppliers to remove the packaging for re-use, before the material is delivered to the site. Use blankets and padding to protect supplies against damage on site.
iv. Inspect all materials on delivery and return any damaged stock to the supplier.
v. Try to leave as many trees, stumps, branches and other vegetation in place on a site when clearing. This will reduce the generation of solid waste. When cut, green waste will need to be disposed of properly
vi. Maintain separate waste streams to increase potential for reuse and recycling of materials. Don’t combine hazardous waste with non-hazardous wastes, as this increases contamination rates, resulting in more waste having to be treated as hazardous.
vii. Select products that will produce the least amount of waste or the least amount of toxic waste. For example, use water based paints rather than oil based or paints containing metal, as left-over paint will be easier to dispose.
viii. Require subcontractors to include the cost of removing their waste in their bids to give them an incentive to produce less waste.

ix. Prior to commencing a construction project, evaluate materials required and make an effort to purchase previously used material where possible.
x. Crush used rubble on site and reuse as fill or for bedding on driveways and pathways, instead of purchasing new material.
xi. Joist off-cuts can be cut up and used as stakes for forming or for headers around openings in the floor assembly.
xii. Leftover rigid insulation can be used as ventilation baffles in attics or installed into house envelopes at joist header assemblies.
xiii. Return pallets to the vendors for reuse.
xiv. Plan to keep the salvageable materials that can't be reused on site, separate from other waste streams and then arrange for a recycling contractor to collect.
xv. Investigate the option of deconstruction prior to building, rather than demolition.
xvi. Materials that are unsuitable for reuse might be suitable for recycling. Prior to disposal, sort out the recyclable materials and make arrangements for a contractor to collect. Check with local recycling contractors for details on what can be recycled and how to avoid contamination.

### 2.7.7 Alternatives to Construction Waste Disposal

There are two (2) main alternatives that can be applied which are organizational or governmental regulations that require reuse or recycle of specific building materials during a construction project. A second alternative is 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 too effective. Both options increase labor costs for separation of materials but these costs are offset by the money that is saved.

### 2.7.7.1 Reuse and Recycle

#### 2.7.7.1(a) The Need for Building Waste Minimization

In all communities, it has always been common practice to retrieve valuable materials from the arising waste, for examples, 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 recognised 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, households and so on.

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 (Lauritzen, 2001).

In many countries, industrialised 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 wastes typically include 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).

**2.7.7.1(b)** Goals for Recycling

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 (Lauritzen, 2001).

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).

#### 2.7.7.1(c) Barriers to Recycling

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). There have four (4) barriers to recycling which is:

i) Economy

If the consumption of building materials is regulated solely by the market economy, the choice between recycled an d 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)

ii) 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 responsibly 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 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. (Lauritzen, 2001)

iii) Monitoring and Follow up

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. The system receives detailed information on the handling of all construction and demolition waste in the country. (Lauritzen, 2001)

iv) Certification of Recycled Materials

Owing to tradition and psychological barriers the general attitude towards recycling in the building and construction industry is largely prohibitive towards the utilisation 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)

# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

This chapter briefs on the methodology being applied in conducting the study. Methodology is a preliminary procedure for conducting a study because it is the overarching term that encompasses diverse principles, procedures and practices related to the conduct of research. Various obstacles have been found during the study such as doing the selecting of the sample, assigning the condition, manipulating an independent variable, assessing the effects, and analyzing the results if without a proper and effective methodology. Study involves a process that moves from an idea, planning and executing an investigation, evaluating the results and communicating the finding.

A methodology is way or approach taken in order to achieve the objectives which is to identify types of construction solid waste on site, to identify the causes of construction waste and to analyze the difference of wastage level between residential and commercial building using fabrication method through data collection and analysis. Certain methods and procedures also used to obtain the information needed for the focus question. An organized and suitable study methodology is essential to ensure the effectiveness of the study process. It is very crucial to plan a research methodology properly as different types of research require different methodology.

The methodology chosen must be able to fulfill the needs of the study which are the set of data needed and method of analyzing it which means the methodology applied should be able to produce the required data and provide a correct way to analyze it. Therefore, it is essential to establish a proper and correct methodology for any study from the beginning.

## 3.2 Preliminary Stage of Study

At this stage, preliminary investigation and observation on construction wastage between commercial and residential area by using prefabrication method have been conducted in Selangor and Kuala Lumpur area. Based on the problem selected, frame objectives of the study have been outlined with the real situation. After this, the scope of study has been determined and is followed by the planning of the methodology. The study will be conducted by following the preliminary methodology.

## 3.3 Literature Review

Literature review is essential in helping a researcher to identify existing problems or shortcomings of the issue at hand. It is been established in the beginning of the study that understanding of the issue is very crucial. This is very important in order to be able to see what the key problem is or the real issue before starting a study or in another word, the objective is to collect all the data for the study. As a result, the research objectives, scopes and requirements can be clearly drawn up. All relevant information related to the study was condensed to produce this study. The sources of literature review, among others, are books, journals, magazines, news paper, previous thesis and report. Some information can also be gained through the internet.

### 3.4 Empirical Review

During the empirical stage, the data and information for the study is being collected and analyzed. The data and information for this study are collected from multiple sources in order to wide the net and enable more reliable conclusion to be drawn. The primary sources of data are from questionnaire survey and via interview with a group of the known experts in this study who are contractors, developers and manufacturer.

The data is collected from the case studies of the construction projects which using prefabrication construction method. Information collected is regarding to the wastage level between commercial and residential area. The wastage level is then evaluated and analyzed to be as a result of the third objective of this study.

### 3.4.1 Questionnaires

The main source of information obtained from data analysis is from the questionnaires. The questionnaire is of semi-structured with mostly multiple-choice question. The questionnaire has be mailed to the contractor and developer's companies that located in Selangor and Pahang.

### 3.4.2 Interview

At the same time, some interview will be conducted with several contractors to understand the real situation about the use of prefabrication method in Malaysia and wastages in construction. The interview will be divided into several parts which include the background of the company, position of respondent who was interviewed in the company, company address and contact number for reference. The second part is aimed to get some opinion from the respondents. The questions are about the wastages level in residential and commercial that using prefabrication method.

### 3.4.3 Secondary Data

Secondary data is a data that get from other research. They are first formal appearance of result in the print or electronic literature and usually get from readings, material such as journal, articles, dissertation or thesis, newspaper, magazines and through internet.

## 3.5 Evaluation

The final stage in the methodology part is the evaluation process where all the data is being analyzed by utilizing basic statistical method and the findings from the analysis are being evaluated, discussed and summarized. From the findings, conclusion is made through evaluation and discussion of the findings. Afterwards, some suggestion are proposed based on the conclusion that will improve the whole study.

## 3.6 Analysis Stage

The data collected from the questionnaire survey was analysed using Average Index and Mean.

### 3.6.1 Average Index

The software used to analyse data received from feedback of questionnaire is Microsoft Excel 2007 for Microsoft Windows XP. By using Microsoft Excel 2007, it simplified the calculation of average mean index and easy to generate chart and graph. The average index is calculated based on equation as follows (Al-Hammad and sadi Assaf, 1996)

$$\text{Average Index} = \frac{\Sigma aiXi}{\Sigma Xi}$$

Where,

ai = Constant which represents the weight of i ;
Xi = Variable that represent the respondent frequency for I ;
i = 1, 2, 3, 4, 5.

In the questionnaire survey forms that have been forwarded to various stakeholder, the answering technique used is based on Likert Scale which have been divided into five (5) scale rating categories.

By referring to Majid and McCaffer (1997), the rating scale used for the questionnaire in this study is as follows:

1) "Most Important" $4.50 \leq$ Average Index $< 5.00$
2) "Important" $3.50 \leq$ Average Index $< 4.50$
3) "Average" $2.50 \leq$ Average Index $< 3.50$
4) "Less Important" $1.50 \leq$ Average Index $< 2.50$
5) "Least Important" $1.00 \leq$ Average Index $< 1.50$

## 3.62 Mean

Average wastage level for six (6) types of material in conventional and prefabricated construction is calculated by using Mean (McCaffer, 1997).

*Mean formula:*

$$\bar{X} = \frac{\sum_{i=l}^{k} fi\ xi}{\sum_{i=l}^{k} fi}$$

Where,

$x_{i\,=}$ medium point for each class of waste.

# CHAPTER 4

# ANALYSIS AND RESULTS

## 4.0 Introduction

In this chapter, analysis of wastage level between residential and commercial using prefabrication method is done according to Chapter 3. Data is collected through site visit, and questionnaire. In this section, collected data regarding to the causes of waste and waste preventions will be analyzed using *Average Index(AI)* method, while data of material wastage will be analyzed using Mean.

Questionnaires are sent by post and email to hundred (100) contractor companies, consultant firms and Industrialized Building System (IBS) manufacturers registered under CIDB.

At the end, there are thirty (30) respondents who give their feedback. The number and percentage of respondents is shown in Table 4.1.

**Table 4.1**: Number of questionnaires returned

| | Number of questionnaires | | Percentage of return rate (%) |
|---|---|---|---|
| | Sent | Returned | |
| COMPANY | 100 | 30 | 30 |

The survey form was done in such a way by post and email in order to ensure the contractors are willing to give their fullest co-operation in answering the survey forms. The data and information from the survey forms are recorded and using suitable statistical methods, analyzed appropriately. Data then are disseminated and presented in suitable forms such as charts, tables or graphs. Thus, the data could be interpreted and understood easily.

## 4.2 Data Analysis (Questionnaire Survey)

The analysis from the questionnaire form can divided into four (4) parts which will answer the objectives of the study:

Section A: Analysis and Result of project and respondent's company profile.
Section B: Analysis and Results of factors of construction waste.
Section C: Analysis and Results of method to prevent construction waste.

Section D: Analysis and Results of Percentage estimation for material wastage on site

### 4.2.1 Analysis of Project and Respondent's Company Profile

Background information on the respondents and types of construction projects completed is shown in Table 4.2. The background information consists of data on the company's name, position of respondent, current project and volume of waste generated per day per project.

**Table 4.2**: Number and Percentage of Respondent's on Types of Construction Projects.

| | Number of questionnaires | | Percentage of return rate (%) |
|---|---|---|---|
| | Sent | Returned | |
| RESIDENTIAL | 50 | 16 | 32 |
| COMMERCIAL | 50 | 14 | 28 |
| TOTAL | 100 | 30 | 30 |

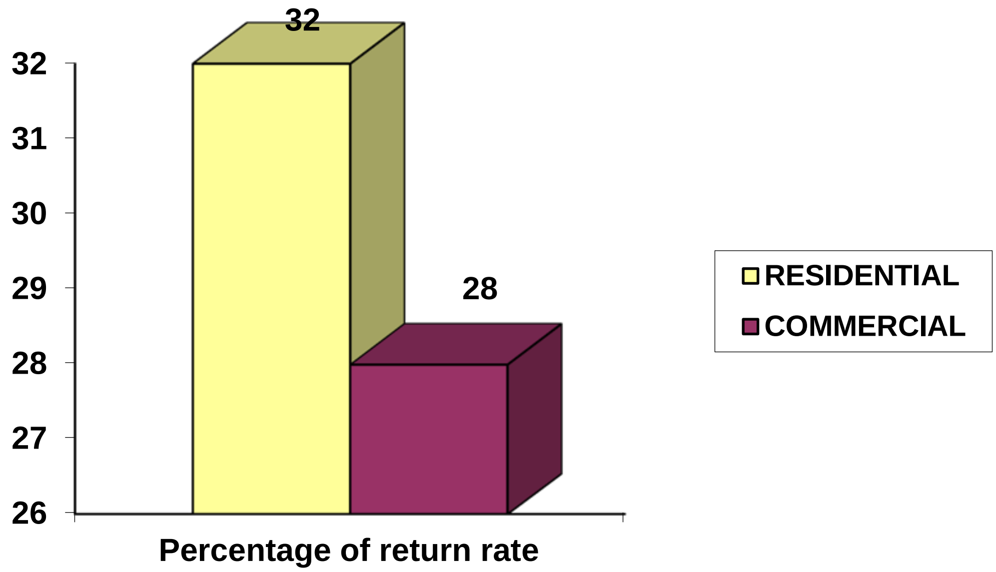



**Figure 4.1:** Types of Construction Projects Already Carried Out by The Various Respondents.

From the figure 4.1, the percentage of return rate for residential is thirty two percent (32%) while for commercial building is twenty eight percent (28%). It shows that the percentage of return rate for residential is higher than commercial building. This is because, the questionnaire has been sent more to the company that doing the residential project.

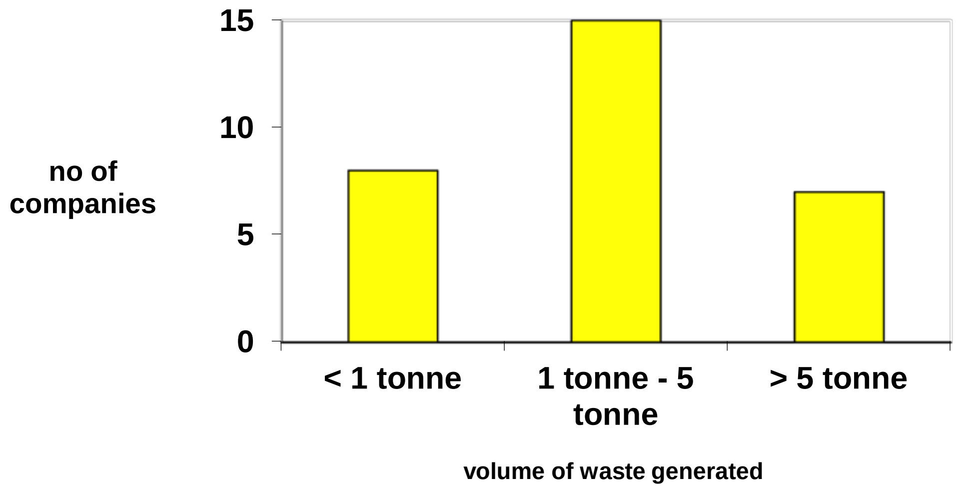



**Figure 4.2**: The Volume of Waste Generated Per Day Per Project

Form the figure 4.2, it shows that eight (8) companies produced less than 1 tonne for the volume of waste generated per day per project. Fifteen (15) companies produces the volume of waste per day per project around one (1) tonne to (5) tonne while seven (7) companies produces the volume of waste per day per project more than five (5) tonne. It shows that most companies produced one (1) tonne to five (5) tone the volume of wastes per day per project.

### 4.2.2 Analysis of Factors of Constructions Waste.

This section will present the frequency of eight (8) factors of construction waste which occurred in prefabrication construction. Frequency of occurrence is rated from one (1) to five (5), where one (1) is the least frequent and five (5) is the most frequent. Finally, the importance of each cause is calculated by using Average Index method (Al-

Hammad and Sadi Assaf, 1996). Table 4.3 and figure 4.3 show the factors of construction wastes in Prefabrication construction.

**Table 4.3**: Factors of Construction Wastes in Prefabrication Construction

| No | Factors of construction waste | No of respondent, $f_i$ | | | | | Total | Average Index (AI) |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | |
| 1 | Design | 1 | 3 | 3 | 12 | 11 | 30 | 3.97 |
| 2 | Procurement | 0 | 3 | 4 | 11 | 12 | 30 | 4.07 |
| 3 | Material Handling | 0 | 0 | 1 | 16 | 13 | 30 | 4.40 |
| 4 | Construction/renovation | 0 | 1 | 7 | 9 | 13 | 30 | 4.13 |
| 5 | Demolition Works | 1 | 3 | 7 | 8 | 11 | 30 | 3.83 |
| 6 | Cultural | 1 | 6 | 8 | 8 | 7 | 30 | 3.47 |
| 7 | Level of knowledge | 0 | 0 | 2 | 11 | 17 | 30 | 4.50 |
| 8 | Lack of communication between leader and worker | 0 | 0 | 2 | 12 | 16 | 30 | 4.47 |

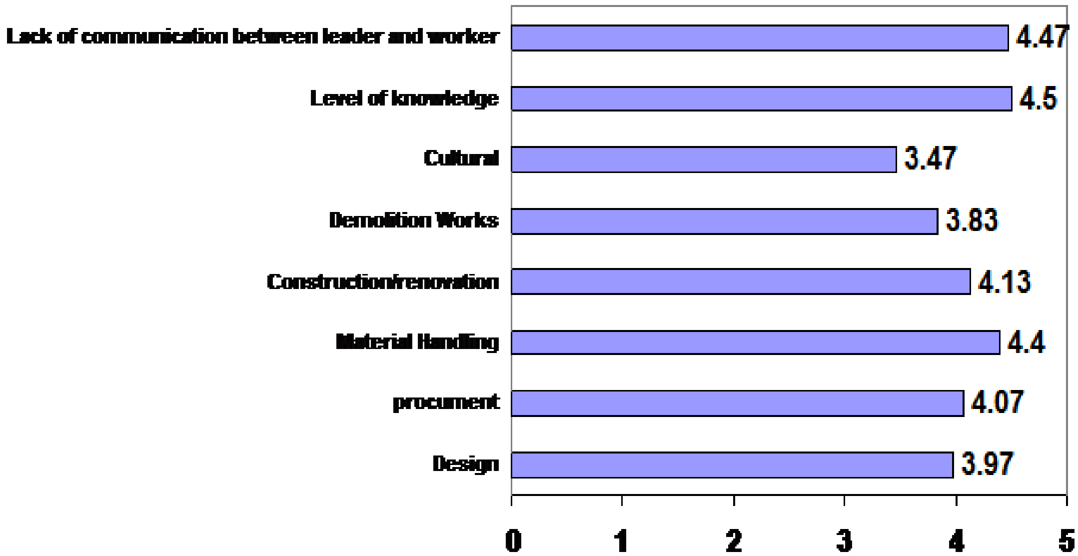



**Figure 4.3:** Factors of Constructions Waste in Prefabrication Construction

Referring to Table 4.3, it was found that level of knowledge is a "very important" factor at an AI of 4.5. This is closely followed by lack of communication between leader and workers with AI value of 4.47. Material handling, construction/renovation, procument, design and demolition work are classified as a "very important" factors at values of 4.4, 4.13, 4.07, 3.97 and 3.98 respectively. The other main contributor of waste is cultural which is 'moderately important' with AI value of 3.47.

This shows that the level of knowledge of the parties involved in construction project is the major factor which contributed to the occurrence of construction waste on site. Therefore, it is very important for all of the parties involved to have a well knowledge and education about how to manage materials on site and in the same time they have to know how to manage waste on site so that the wastage problems can be reduce.

### 4.2.3 Analysis of Method to Prevent Construction Waste

From the Literature Review in Chapter II, few methods have been introduced to prevent the generation of construction wastage on site. In this section, the effectiveness of these waste preventions will be identified through the data obtained from the questionnaires.

Data of waste preventions are analysed by using AI method which can be classified into 5 categories:

| | |
|---|---|
| 1) “Strongly Agree” | $4.50 \leq$ Average Index $< 5.00$ |
| 2) “Agree” | $3.50 \leq$ Average Index $< 4.50$ |
| 3) “No comment” | $2.50 \leq$ Average Index $< 3.50$ |
| 4) “Disagree” | $1.50 \leq$ Average Index $< 2.50$ |
| 5) “Strongly Disagree” | $1.00 \leq$ Average Index $< 1.50$ |

**Table 4.4:** Methods of Waste Prevention

| No | Methods of waste prevention | No of respondent, fi | | | | | Total | Average Index |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | |
| 1 | Use standard material sizes for building designs. | 2 | 13 | 2 | 13 | 12 | 30 | 4.87 |
| 2 | Require subcontractors to include the cost of removing their waste in their bids | 3 | 0 | 4 | 11 | 12 | 30 | 3.97 |
| 3 | Participation in the waste minimization programmed from all parties | 1 | 2 | 7 | 14 | 6 | 30 | 3.73 |
| 4 | Avoiding damage while stored on site and additional moving of materials. | 1 | 2 | 1 | 17 | 9 | 30 | 4.03 |
| 5 | Prepare suitable vehicles or delivery plants for transporting material. | 2 | 2 | 2 | 20 | 4 | 30 | 3.73 |
| 6 | Adopt just-in-time ordering; ensure materials arrive on site when they are needed. | 1 | 0 | 0 | 23 | 6 | 30 | 4.10 |
| 7 | Inform the suppliers of the construction process requirements and order the materials in good time for the whole site | 1 | 1 | 10 | 12 | 6 | 30 | 3.70 |

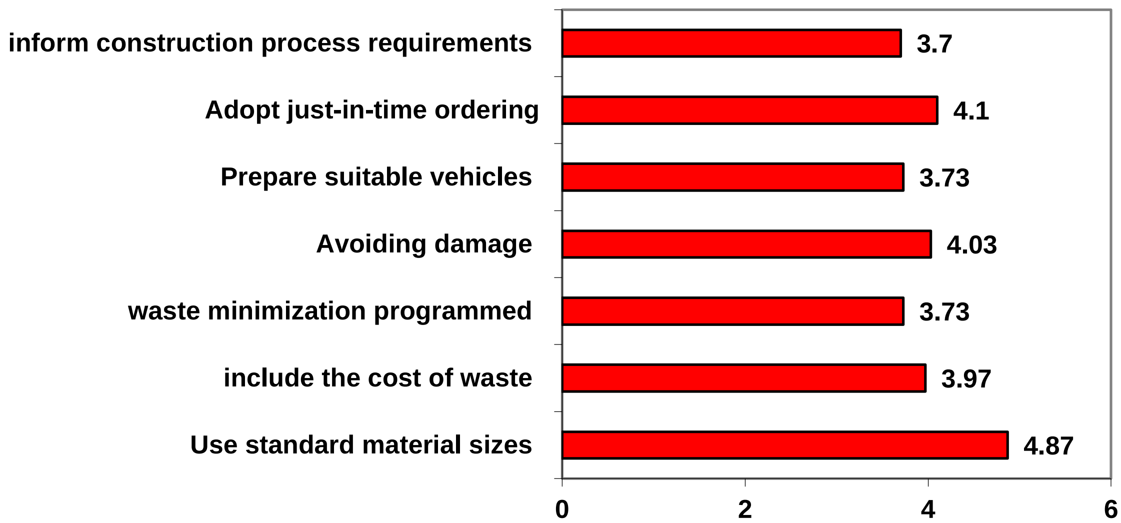



**Figure 4.4:** Efficiency of Waste Prevention

Table 4.4 shows the most effective method to prevent the construction waste is use standard material sizes for building designs with show the highest AI of 4.87 and it is in the category of “Strongly Agree”. Adopt just-in-time ordering and ensure materials arrive on site when they are needed is investigated to be an effective waste prevention, with the second highest AI of 4.1 and in the category of “Agree”. It is closely followed by avoiding damage while stored on site and additional moving of materials at an AI value of 4.03 at the same category of “Agree”.

Require subcontractors to include the cost of removing their waste in their bids is an effective method to reduce construction waste with the average index of 3.97 in the category of “Agree”. Participation in the waste minimization programmed from all parties and prepare suitable vehicles or delivery plants for transporting material having the same values of AI which is 3.73 in category of “Agree”. Finally, inform the suppliers of the construction process requirements and order the materials in good time for the whole site is the least important method compared to other six (6) method, but it still in the category of “Agree” with the value of AI is 3.70.

This shows that to use the standard material sizes for building is important to prevent the wastage in construction site. Therefore, engineers must make sure the material sizes are correct before start the construction.

### 4.2.4 Analysis of the Material Wastage Level for Residential Using Prefabrication Method

This section is presenting the analysis of material wastage level in conventional and prefabrication construction. There are six (6) types of commonly used construction materials to be investigated which are steel, brick, timber, concrete, plastic, paper. The wastage level is presented in terms of percentage in quantity. Percentage of material wastage level is divided into four (4) classes which shown in Table 4.5 and Table 4.6. Table 4.5 shows the wastage level of each material in residential and Table 4.6 shows wastage level of each material in commercial building.

The data provided are based on respondent’s experience but not on any specific project or construction site. This is because most of the construction projects do not have any specific record regarding to material wastage, so the information given is an assumption and most probably do not based on any detail record.

Regarding the data of material wastage level in prefabrication construction, some of the respondents do not provide the information of wastage level for all of the six (6) materials, because some certain construction materials are not applicable in construction project they handled and they do not have any experience with those particular construction materials.

Every data is collected according to each types of material for residential and commercial building. The average percentage of wastage level is calculated by using formula of Mean. Finally, mean of material wastage in residential and commercial building is to be compared according to the six (6) types of material.

**Table 4.5:** Wastage Level of Each Material in Residential

| Percentage of wastage (%) | Frequency | | | | | | |
|---|---|---|---|---|---|---|---|
| | Concrete | Timber | Steel | Brick | Plastic | Paper | Other |
| 0 – 5 | 1 | 4 | 7 | 3 | 10 | ` 10 | 7 |
| 6 – 10 | 7 | 3 | 4 | 6 | 5 | 4 | 7 |
| 11 – 15 | 4 | 3 | 5 | 5 | 0 | 1 | 1 |
| 16 – 20 | 4 | 4 | 0 | 1 | 0 | 0 | 0 |
| >20 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Total | 16 | 15 | 16 | 15 | 15 | 15 | 15 |

**Table 4.6:** Wastage Level of Each Material in Commercial Building

| Percentage of wastage (%) | Frequency | | | | | | |
|---|---|---|---|---|---|---|---|
| | Concrete | Timber | Steel | Brick | Plastic | Paper | Other |
| 0 – 5 | 4 | 4 | 7 | 5 | 10 | ` 10 | 8 |
| 6 – 10 | 7 | 7 | 6 | 4 | 4 | 4 | 5 |
| 11 – 15 | 2 | 1 | 1 | 5 | 0 | 0 | 1 |
| 16 – 20 | 1 | 2 | 0 | 0 | 0 | 0 | 0 |
| >20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 14 | 14 | 14 | 14 | 14 | 14 | 14 |

### 4.2.5 Wastage Level of Concrete in Residential and Commercial Building

**Table 4.7:** Wastage Level of Concrete

| **Percentage of wastage (%)** | **Middle Point, $x_i$** | **Residential** | | | **Commercial** | | |
|---|---|---|---|---|---|---|---|
| | | **Frequency, $f_i$** | **$f_ix_i$** | **%** | **Frequency, $f_i$** | **$f_ix_i$** | **%** |
| 0 – 5 | **2.5** | 1 | **2.5** | **6.25** | 4 | **10** | **28.6** |
| 6 – 10 | **8** | 7 | **56** | **43.75** | 7 | **56** | **50** |
| 11 – 15 | **13** | 4 | **52** | **25** | 2 | **26** | **14.3** |
| 16 – 20 | **18** | 4 | **72** | **25** | 1 | **18** | **7.1** |
| >20 | **22** | 0 | **0** | **0** | 0 | **0** | **0** |
| **Total** | | **16** | **182.5** | **100** | **14** | **110** | **100** |

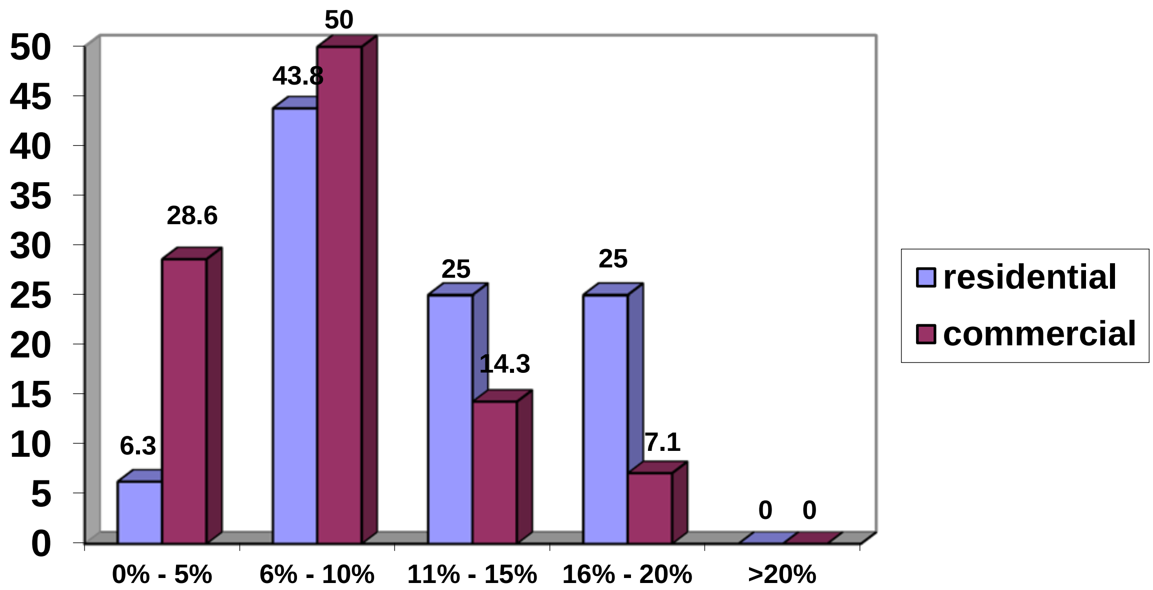



**Figure 4.5 :** Percentage of Frequency versus Wastage Level of Concrete

Table 4.7 and Figure 4.5 show the frequency for each category of concrete wastage level in residential and commercial building based on number and percentage of respondent. There are fives (5) categories of wastage level vary from 0% to 20%. In residential, it is shown that difference frequency rate in each of five (5) categories. 6.25% of the respondents state that the percentage of concrete wastage is in the range of 0% - 5%. Thus, average wastage levels for residential and commercial are 11.4% and 7.86% respectively. The percentage of reduction by using prefabrication is 31.1%.

This shows that average wastage level for residential is more than commercial building. Concrete lost through excessive material ordering, broken formwork and redoing due to poor concrete placement quality.

### 4.2.6 Wastage Level of Timber in Residential and Commercial Building

**Table 4.8:** Wastage Level of Timber

| **Percentage of wastage (%)** | **Middle Point, $x_i$** | **Residential** | | | **Commercial** | | |
|---|---|---|---|---|---|---|---|
| | | **Frequency, $f_i$** | **$f_i x_i$** | **%** | **Frequency, $f_i$** | **$f_i x_i$** | **%** |
| 0 - 5 | **2.5** | 4 | **10** | **26.7** | 4 | **10** | **28.6** |
| 6 - 10 | **8** | 3 | **24** | **20** | 7 | **56** | **50** |
| 11 - 15 | **13** | 3 | **39** | **20** | 1 | **13** | **7.1** |
| 16 - 20 | **18** | 4 | **72** | **26.7** | 2 | **36** | **14.3** |
| >20 | **22** | 1 | **22** | **6.6** | 0 | **0** | **0** |
| **Total** | | **15** | 167 | **100** | **14** | 115 | **100** |

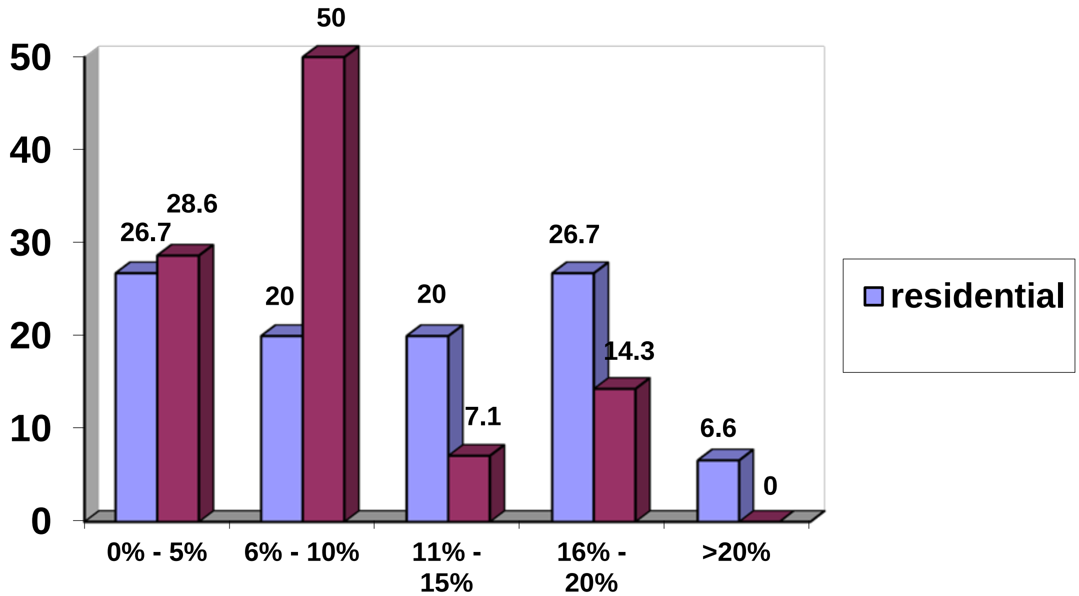



**Figure 4.6:** Percentage of Frequency versus Wastage Level of Timber

Table 4.8 and Figure 4.6 show the frequency for each category of timber wastage level in residential and commercial building based on number and percentage of respondent. There are five (5) categories of wastage level varies from 0% to 20%. In residential, it shows that most of the respondent which 26.7% of them stated that the percentage of timber wastage is in range 0% - 5% and 16% - 20% while in commercial building, most of the respondent (50%) stated that the percentage of timber wastage is in range 6% - 10%. Thus, average wastage levels for residential and commercial are 11.1% and 8.21% respectively. The percentage of reduction by using prefabrication method is 26%.

This shows that residential building has a highest average wastage for timber material. This is because, in residential building, quantity timber that using in construction site more than commercial building.

### 4.2.7 Wastage Level of Steel in Residential and Commercial Building

**Table 4.9:** Wastage level of Steel

| Percentage of wastage (%) | Middle Point, $x_i$ | Residential | | | Commercial | | |
|---|---|---|---|---|---|---|---|
| | | Frequency, $f_i$ | $f_i x_i$ | % | Frequency, $f_i$ | $f_i x_i$ | % |
| 0 - 5 | **2.5** | 7 | **17.5** | **43.8** | 7 | **17.5** | **50** |
| 6 - 10 | **8** | 4 | **32** | **25** | 6 | **48** | **42.9** |
| 11 - 15 | **13** | 5 | **65** | **31.2** | 1 | **13** | **7.1** |
| 16 - 20 | **18** | 0 | **0** | **0** | 0 | **0** | **0** |
| >20 | **22** | 0 | **0** | **0** | 0 | **0** | **0** |
| **Total** | | **16** | 114.5 | **100** | **14** | 78.5 | **100** |

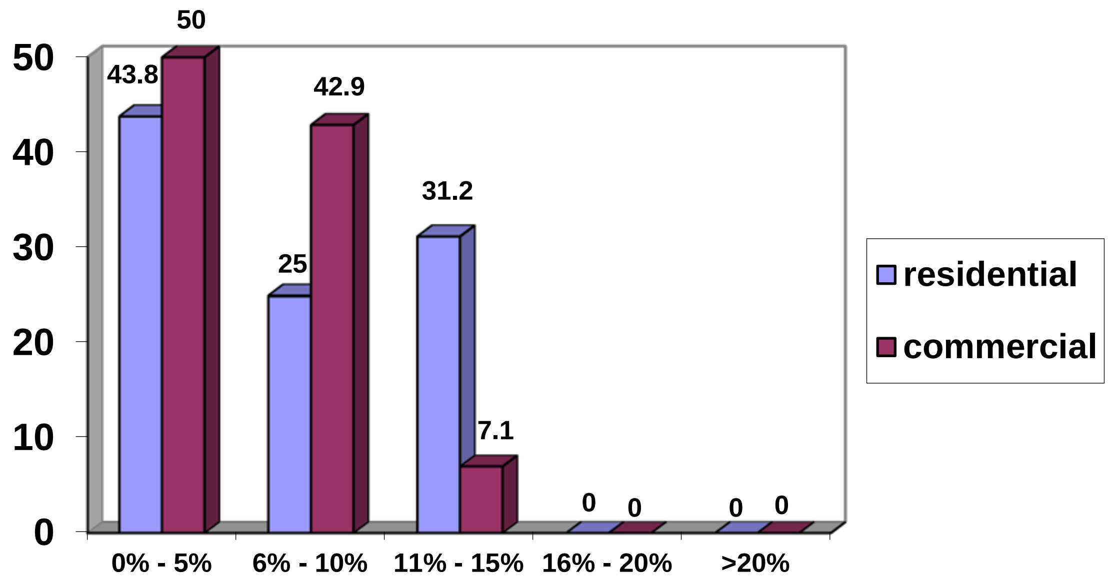



**Figure 4.7:** Percentage of Frequency versus Wastage Level of Steel

Table 4.9 and Figure 4.7 show the frequency for each category of steel wastage level in residential and commercial building based on number and percentage of respondent. There are five (5) categories of wastage level varies from 0% to 20%. From the graph, it shows both residential and commercial building have the same respondents who stated that the percentage of timber wastage is in range 0% - 5% with 50% for commercial and 43.3% for residential. Thus, average wastage levels for residential and commercial are 7.16% and 5.61% respectively. The percentage of reduction by using prefabrication method is 21.6%.

From the results, it shows that average wastage for residential is higher that commercial. Factors that contributed the wider range of steel waste resulted lead by excessive order and cutting error due to the design unplanned changes. This result is supported by Rounce (1998) which pointed out that the major construction waste sources are at design stage, such as design changes, the variability in the level of design details. projects, the achievement on the performance in waste reduction will be much better (Tam et al 2006).

### 4.2.8 Wastage Level of Brick in Residential and Commercial Building

**Table 4.10:** Wastage Level of Brick

| **Percentage of wastage (%)** | **Middle Point, $x_i$** | **Residential** | | | **Commercial** | | |
|---|---|---|---|---|---|---|---|
| | | **Frequency, $f_i$** | **$f_i x_i$** | **%** | **Frequency, $f_i$** | **$f_i x_i$** | **%** |
| 0 – 5 | **2.5** | 3 | **7.5** | **20** | 5 | **12.5** | **35.7** |
| 6 – 10 | **8** | 6 | **48** | **40** | 4 | **32** | **28.6** |
| 11 - 15 | **13** | 5 | **65** | **33.3** | 5 | **65** | **35.7** |
| 16 - 20 | **18** | 1 | **18** | **6.7** | 0 | **0** | **0** |
| >20 | **22** | 0 | **0** | **0** | 0 | **0** | **0** |
| **Total** | | **15** | 138.5 | **100** | **14** | 109.5 | **100** |

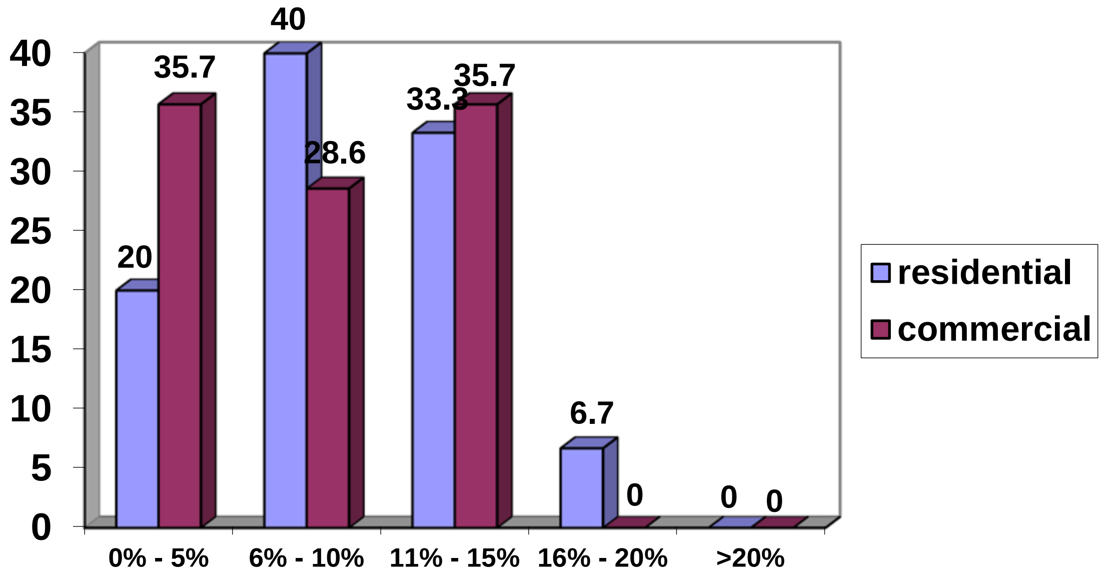



**Figure 4.8 :** Percentage of Frequency versus Wastage Level of Brick

Table 4.10 and Figure 4.8 show the frequency for each category of brick wastage level in residential and commercial building based on number and percentage of respondent. There are five (5) categories of wastage level varies from 0% to 20%. In residential, it shows most of respondent the (40%) stated that the percentage of timber wastage is in range 6% - 10% while in commercial building, most of them which (35.7%) stated that the percentage of timber wastage is in range 0% - 5% and in range 11% - 15%. Thus, average wastage levels for residential and commercial are 9.23% and 7.82% respectively. The percentage of reduction by using prefabrication method is 15.28%.

Result shows that wastage level in residential building more than commercial building. This is because, there having a problem during ordering the bricks, over ordering, supplier's error and so on. Faults in taking-off, unfinished detailing and small quantity of materials required in renovation work are the main cause of over-ordering.

### 4.2.9 Wastage Level of Plastic in Residential and Commercial Building

**Table 4.11:** Wastage Level of Plastic

| Percentage of wastage (%) | Middle Point, $x_i$ | Residential | | | Commercial | | |
|---|---|---|---|---|---|---|---|
| | | Frequency, $f_i$ | $f_i x_i$ | % | Frequency, $f_i$ | $f_i x_i$ | % |
| 0 - 5 | **2.5** | 10 | **25** | **66.7** | 10 | **25** | **71.4** |
| 6 - 10 | **8** | 5 | **40** | **33.3** | 4 | **32** | **28.6** |
| 11 - 15 | **13** | 0 | **0** | **0** | 0 | **0** | **0** |
| 16 - 20 | **18** | 0 | **0** | **0** | 0 | **0** | **0** |
| >20 | **22** | 0 | **0** | **0** | 0 | **0** | **0** |
| **Total** | | **15** | 65 | **100** | **14** | 57 | **100** |

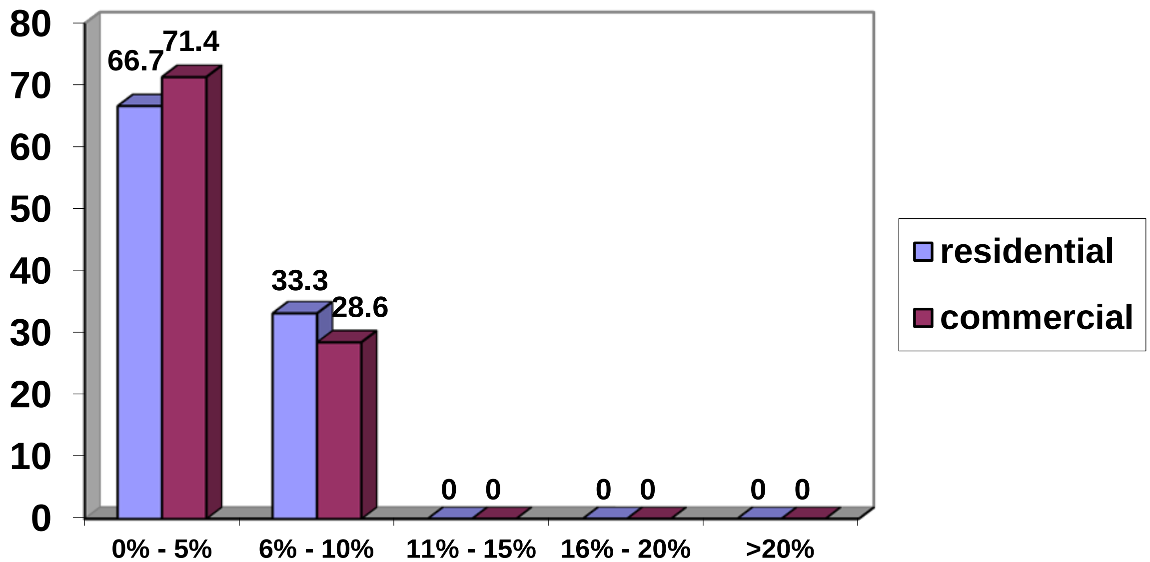



**Figure 4.9:** Percentage of Frequency versus Wastage Level of Plastic

Table 4.11 and Figure 4.9 show the frequency for each category of plastic wastage level in residential and commercial building based on number and percentage of respondent. There are five (5) categories of wastage level varies from 0% to 20%. From the graph, it shows both residential and commercial building have the most of respondent who stated that the percentage of timber wastage is in range 0% - 5% with 71.4% for commercial and 66.7% for residential. Thus, average wastage levels for residential and commercial are 4.33% and 4.07% respectively. The percentage of reduction by using prefabrication method is 6.0 %.

Residential building has a higher average wastage level for plastic compared to commercial building. This is because, it has problems during handling the materials. The major cause of material wastage due to improper handling is the attitude of project team and labourers. The building components were damaged during delivery because of insufficient protection during loading and unloading.

### 4.2.10 Wastage Level of Paper in Residential and Commercial Building

**Table 4.12:** Wastage level of Paper

| **Percentage of wastage (%)** | **Middle Point, $x_i$** | **Residential** | | | **Commercial** | | |
|---|---|---|---|---|---|---|---|
| | | **Frequency, $f_i$** | **$f_i x_i$** | **%** | **Frequency, $f_i$** | **$f_i x_i$** | **%** |
| 0 - 5 | **2.5** | ` 10 | **25** | **66.7** | ` 10 | **25** | **71.4** |
| 6 - 10 | **8** | 4 | **32** | **26.7** | 4 | **32** | **28.6** |
| 11 - 15 | **13** | 1 | **13** | **6.7** | 0 | **0** | **0** |
| 16 - 20 | **18** | 0 | **0** | **0** | 0 | **0** | **0** |
| >20 | **22** | 0 | **0** | **0** | 0 | **0** | **0** |
| **Total** | | **15** | 70 | **100** | **14** | 57 | **100** |

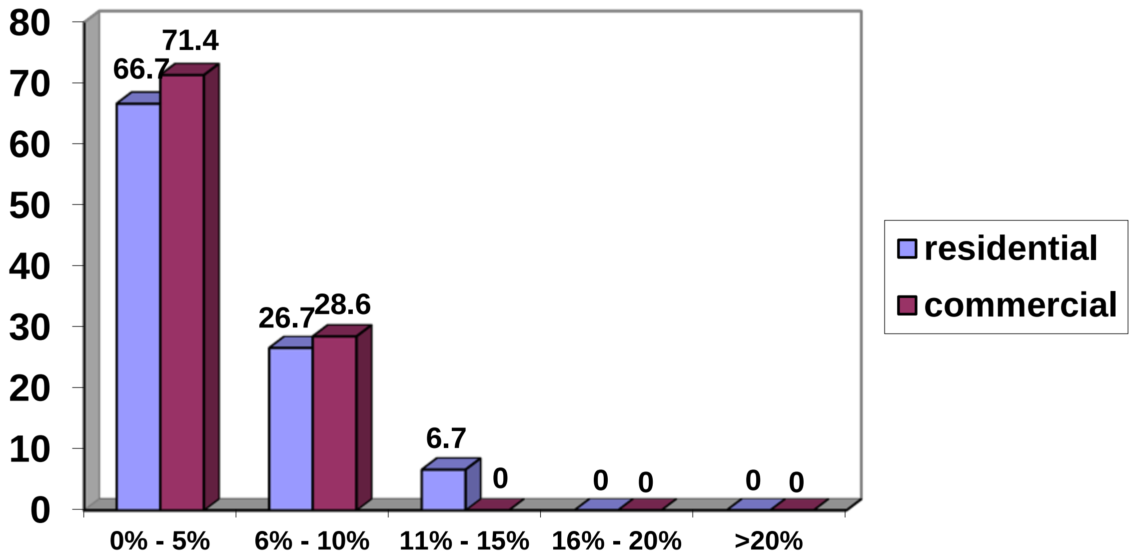



**Figure 4.10:** Percentage of Frequency versus Wastage Level of Paper

Table 4.12 and Figure 4.10 show the frequency for each category of paper wastage level in residential and commercial building based on number and percentage of respondent. There are five (5) categories of wastage level varies from 0% to 20%. From the graph, it shows both residential and commercial building have most of respondents stated that the percentage of timber wastage is in range 0% - 5% with 71.4% for commercial and 66.7% for residential. Thus, average wastage levels for residential and commercial are 4.67% and 4.07% respectively. The percentage of reduction by using prefabrication method is 12.8 %.

This shows that average wastage level for residential is more than commercial building. Lack of education about the environment can result wastage in construction especially for paper.

### 4.2.11 Wastage Level of Other Material in Residential and Commercial Building

**Table 4.13:** Wastage Level of Other Material

| Percentage of wastage (%) | Middle Point, $x_i$ | Residential | | | Commercial | | |
|---|---|---|---|---|---|---|---|
| | | Frequency, $f_i$ | $f_i x_i$ | % | Frequency, $f_i$ | $f_i x_i$ | % |
| 0 - 5 | **2.5** | 7 | **25** | **66.7** | 8 | **20** | **57.1** |
| 6 - 10 | **8** | 7 | **32** | **26.7** | 5 | **40** | **35.7** |
| 11 - 15 | **13** | 1 | **13** | **6.7** | 1 | **13** | **7.2** |
| 16 - 20 | **18** | 0 | **0** | **0** | 0 | **0** | **0** |
| >20 | **22** | 0 | **0** | **0** | 0 | **0** | **0** |
| **Total** | | **15** | 70 | **100** | **14** | 73 | **100** |

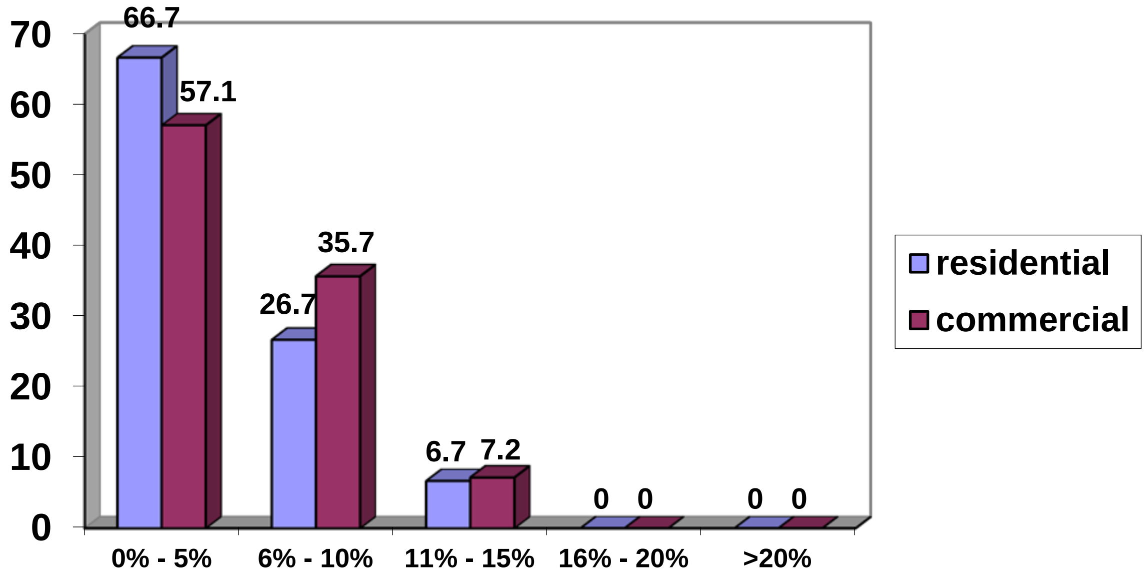



**Figure 4.11:** Percentage of Frequency versus Wastage Level of Other Material

Table 4.13 and Figure 4.11 show the frequency for each category of other material wastage level in residential and commercial building based on number and percentage of respondent. There are five (5) categories of wastage level varies from 0% to 20%. From the graph, it shows both residential and commercial building have most of the respondents who stated that the percentage of timber wastage is in range 0% - 5% with 71.4% for commercial and 66.7% for residential. Thus, average wastage levels for residential and commercial are 4.33% and 4.07% respectively. The percentage of reduction by using prefabrication method is 6.0 %.

This shows that average wastage levels in residential more than commercial building for other material. Other material, such as tile and cement more in residential because, the size of the project in residential mostly more than commercial that using prefabrication method.

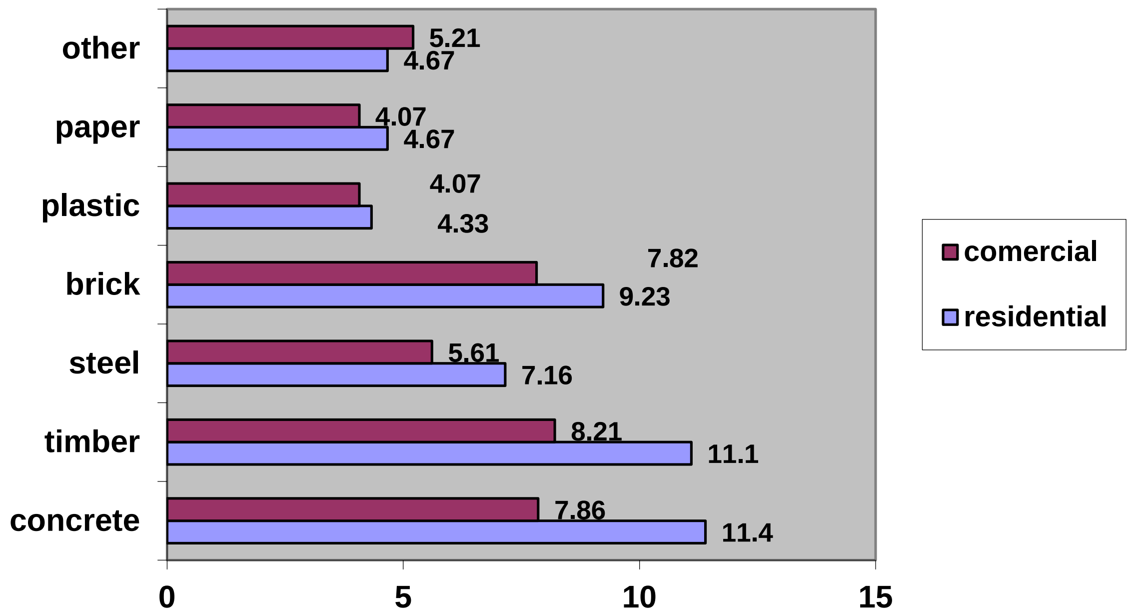



**Figure 4.12:** Average Wastage for Materials in Residential and Commercial Building

From the Figure 4.93 above, the most average wastage in residential is concrete with the value of 11.4. It is followed by timber (11.1), brick (9.23), steel (7.16), other material (4.67), paper (4.67) and the less average wastage is plastic with the value of 4.33. Concrete has a highest wastage because it is common material that using in construction so if more material that have been used, the more wastage will produce. Besides that, concrete is one of a material that cannot be recycle, so the balance of concrete that not been used become wastage. Plastic has a lowest wastage because the quantity of plastic using in construction site is less than other materials.

In commercial building, the most average wastage is timber with the value of 8.21. Timber is the most wasted material because its low durability and low reusability. Timber also easy to damage so the wastage is higher. It is followed by concrete (7.86), brick (7.82), steel (5.61) and other material (5.21). The less average wastage is paper and plastic that having a same value which are 4.07.

# CHAPTER 5

# CONCLUSION AND RECOMMENDATION

## 5.1 Introduction

In this section, conclusion will be made to answer three (3) objectives of this study while the recommendation is to be made based on personal observation and knowledge and recommendation for further studies is suggested to overcome the weaknesses of this study.

## 5.2 Conclusion

After data analysis has been completed, it is found that all the three (3) objectives have been achieved. The conclusion that can be drawn from this study are as follows:

### 5.2.1 Objective 1: Identify Types of Construction Solid Waste on Site

The first objective of this study is to identify types of construction solid waste on site. The types of construction solid waste material that have been identified are shown in ranking (for residential building) as follows:

1) Concrete (11.4%)
2) Timber (11.1%)
3) Brick (9.23%)
4) Steel (7.16%)
5) Paper (4.67%)
6) Other (4.67%)
7) Plastic (4.33%)

The types of construction solid waste material that have been identified are shown in ranking (for commercial building) as follows:

1) Timber (8.21%)
2) Concrete (7.86%)
3) Brick (7.82%)
4) Steel (5.61%)
5) Other (5.21%)
6) Paper (4.07%)
7) Plastic (4.07)

### 5.2.2 Objective 2: To Identify the Causes of Construction Waste

The identification of causes of construction waste has been successfully achieved. The causes of construction material waste identified are shown in ranking according to its importance and frequency that using Average Index (AI):

1) Lack of communication between leader and worker (4.47)
2) Level of knowledge (4.5)
3) Material handling (4.4)
4) Construction/renovation (4.13)
5) Procument (4.07)
6) Design (3.97)
7) Demolition works (3.83)
8) Cultural (3.47)

### 5.2.3 Objective 3: Analysis the Difference of Wastage Level between Residential and Commercial Building using Prefabrication Method.

From the data analysis that have been done, it is found that the wastage level in commercial building is lower than in residential building. Data for average wastage for six (6) types of material in residential building and commercial building is summarized in Table 5.1.

**Table 5.1**: Average Wastage for Types of Material

| Material | Average Wastage Level | | Waste Reduction ( C=A-B) | % of Reduction (C /A) |
|---|---|---|---|---|
| | Residential(A) | Commercial (B) | | |
| Concrete | 11.4 | 7.86 | 3.54 | 31.1% |
| Timber | 11.1 | 8.21 | 2.89 | 26.0 |
| Steel | 7.16 | 5.61 | 1.55 | 21.6 |
| Brick | 9.23 | 7.82 | 1.41 | 15.3 |
| Paper | 4.67 | 4.07 | 0.6 | 12.8 |
| Other (aggregate, roofing) | 4.67 | 5.21 | 0.54 | 10.4 |
| Plastic | 4.33 | 4.07 | 0.26 | 6 |

## 5.3 Recommendations

From the conclusions that have been made, it is proved that residential area will generate less material waste than commercial building. It is important to make sure the knowledge in this study is effectively applied to construction practices and few recommendation are suggested as below:

a) Construction builders must set an example and ensure that waste minimization practices are adopted and facilitated on their building sites. In particular, there is a need for construction builders to raise subcontractor's awareness for the impact of their work practices on the generation of construction waste.

b) Project managers must understand who is producing the majority of the waste, target those subs for review and assist subs in identify reduction options.

c) Contractors must be educated about possible cost savings from measures which successfully prevent construction waste, as well as the environmental impacts of the waste and the its long-term national and global implication. The merits of waste minimization and environment protection must also be promoted.

d) Provide reminders at safety or other regular meetings of the project's waste reduction goals. Use these meetings to report progress, discuss problems and discuss specific actions that can be taken. Site success in developing a waste reduction plan depends on a company's ability to implement an effective labor force to carry out the effort. One cannot expect a laborer, carpenter, or mason to simply adopt a waste management culture on his or her own. This makes it clear from the beginning that waste reduction, reuse, and recycling is expected from all crew members.

## 5.4 Recommendation for Further Study

The result of this study has successfully answered the objectives, however this study still need some improvising because there are still many other aspects need to go deep into. There are few suggestion for future study as stated as below:

a) Conduct few case studies on procedure of waste management in prefabrication construction.

b) Study on the efficiency of on site sorting in Malaysia construction industry.

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# APPENDIX

Please tick [ ] in the space provided to indicate your responses.

PART 1: Project and respondent's company profile

1. Company Name :____________________________________________________
2. Position: _________________________________________________________
3. Current Project :____________________________________________________

4. Type of current construction project that have been carried out by the company.

   a) commercial building [ ]
   b) residential building [ ]

5. Volume of waste generated per day per project.

   a) < 1 tonne [ ]
   b) 1 tonne – 5 tonnes [ ]
   c) > 5 tonne [ ]

PART 2: Factors of Waste

Please tick [ ] in the space provided to indicate your responses.

1. Construction waste is generated by many factors. Please rank them accordingly.

① Least important ②Less important ③ Moderately Important ④ Very Important ⑤ Most Important

a) Design ① ② ③ ④ ⑤
b) Procurement ① ② ③ ④ ⑤
c) Material Handling ① ② ③ ④ ⑤
d) Construction/renovation ① ② ③ ④ ⑤
e) Demolition Works ① ② ③ ④ ⑤
f) Cultural ① ② ③ ④ ⑤
g) Level of knowledge ① ② ③ ④ ⑤
h) Lack of communication between leader and worker ① ② ③ ④ ⑤

PART 3: Method to Prevent Construction Waste:

① Strongly Agree ② Agree ③ No comment ④ Disagree ⑤ Strongly Disagree

a) Use standard material sizes for building designs. ① ② ③ ④ ⑤

b) Require subcontractors to include the cost of removing their waste in their bids. ① ② ③ ④ ⑤

c) Participation in the waste minimization programmed from all parties ① ② ③ ④ ⑤

d) Avoiding damage while stored on site and additional moving of materials. ① ② ③ ④ ⑤

e) Prepare suitable vehicles or delivery plants for transporting material. ① ② ③ ④ ⑤

f) Adopt just-in-time ordering; ensure materials arrive on site when they are needed. ① ② ③ ④ ⑤

g) Inform the suppliers of the construction process requirements and order the materials in good time for the whole site. ① ② ③ ④ ⑤

PART 4: Percentage estimation for material wastage on site.

Please tick [✓] in the space provided to indicate your responses

| MATERIAL | PERCENTAGE ESTIMATION % | | | | |
|---|---|---|---|---|---|
| | 0 - 5 | 6 – 10 | 11 – 15 | 16 – 20 | >20 |
| CONCRETE | | | | | |
| TIMBER | | | | | |
| STEEL | | | | | |
| BRICK | | | | | |
| PLASTIC | | | | | |
| PAPER | | | | | |
| OTHER | | | | | |

Thank you for your full co-operation. We are highly appreciate it.