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CONSTRUCTION WASTE: A COMPARATIVE STUDY BETWEEN CONVENTIONAL AND PREFABRICATION CONSTRUCTION METHOD

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BY

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DECLARATION BY THE CANDIDATE

I, Christina Chai Lee Na (I13002484) confirm that the work in this report is my own work and the appropriate credit has been given where references have been made to the work of the other researchers.

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ABSTRACT

Issue of construction waste is getting serious in the recent years. The generation of waste in construction industry will soon affect to the environmental issue. The rate of the wastage level is relatively high in Malaysia. The method of construction used in constructing a building is crucial as it can help to reduce the generation of material waste. In line with this, the study is carried out to analyse the types of construction waste in conventional method and prefabrication method and investigate the level of material wastage between conventional method and prefabrication method. The scope of this study mainly focuses on the contractor's firm registered under Construction Industry Development Board (CIDB) located in Kuala Lumpur. This study is conducted by using questionnaire survey. The data were obtained and analysed by using frequency analysis, average index analysis and mean analysis. From the study the top three types of material were analysed which are timber formwork, concrete and steel reinforcement. According to the comparison of wastage level between conventional method and prefabrication method, the best method in producing less material waste is prefabrication method.

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A.I	Average Index
CIDB	Construction Industry Development Board
TIFAC	Technology Information Forecasting Assessment Council

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

In Malaysia, construction wastes have become a serious concern in recent years. The level of construction waste is relatively high and estimated to exist in construction industry. Construction waste generated gives an adverse effect to the environment. Therefore, a suitable measure must be carried out to prevent the level of wastage keep going up.

"Malaysia is one of the single largest waste streams and yet despite a number of government policy initiatives to address this issue, sustainable resource and waste management on site remains a low priority for the majority of the contractors" (Begum *et al.*, 2009).

As concern grows on the amount of wastes produced in the construction industry, choosing a suitable type of construction method is one of the right ways to overcome the construction wastes.

The type of construction method adopted in construction industry can reduce the growth of material wastage on site. Besides that, recycling of construction waste can be practiced in the construction industry. In many situations, most of the construction waste can be recycled. For example during the renovation works, most of the people will replace the old windows, doors or frame to a new one. Replacing a new item mean the production of the old items as construction waste. In this case, old windows, doors and frame are recyclable.

Based on TIFAC - 'Technology Information Forecasting Assessment Council', soil, sand and gravel, bricks and masonry, concrete, metals, bitumen, wood and etc are mostly produced as a waste. According to the report of TIFAC, the total estimate of 12.0 to 14.7 million tons of waste produced per year. Table below shows the constituent and the quantity of construction waste per year in India.

Table 1.1: Constituent and the quantity of construction waste per year (TIFAC, 2001)

Constituent	**Quantity generated in million tonnes per annum**
Soil, sand and gravel	4.20 to 5.14
Bricks and masonry	3.60 to 4.40
Concrete	2.40 to 3.67
Metals	0.60 to 0.73
Bitumen	0.25 to 0.30
Wood	0.25 to 0.30
Others	0.10 to 0.15

1.2 Problem Statements

The issue of minimizing construction waste which cause significant impacts on the environment is pressing for the Malaysian construction industry. With increasing demand for major infrastructure projects, commercial buildings and housing development programmers, large amounts of construction waste are being produced (Begum *et al.*, 2010).

The result from a case study shows that in Kuching, about 175,000 tons of wastes were produced in a year, and in excess of 100,000 tons were produced yearly in Kota Samarahan from The Star, Manyin (2006).

There was news reported about the construction waste in Malaysia's newspaper. New Straits Times reported the dumping ground situated at Jalan Travers Police Station which will bring on health problems for citizens there. Noel (2013), the reporter reported that more than a month ago, the waste was throw in an open garbage bags filled with rotten food, materials from construction, discarded timber planks and other building materials.

According to Lee (2012) in The Stars Online, "the present rate of wastage of construction materials from discarded leftovers of housing and commercial complex construction projects is still too high at Miri". He then added "as much as 15% to 20% of construction materials like steel bars, wood, broken bricks and sand and gravel did not get to be used, hence were discarded". In addition,

he also said that "the western countries also adopt the methods of using pre-fabricated components for their construction projects so that raw materials can be saved".

The construction waste issues had been reported by the news in Malaysia. According to New Straits Times, Veena (2013) stated that there were formerly 74 hotspots for illegal dumping in the city (Kuala Lumpur).

A study done in Johor district alone indicated there are 42% of 46 illegal dumping sites are of construction waste (Rahmat and Ibrahim, 2007).

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

According to The Stars Online, Stuart (2013) described that "the area surrounding the Chinese and Christian cemeteries in Meru Klang had become a dumping ground and also an open burning site which the lorries from the nearby construction area had been dumping construction waste in the area for the past two years".

1.3 Importance of the Study

The significance of this research is to give the consciousness to all the parties involved in the construction industry about the rate of wastage produced in Malaysia is getting higher and higher. The method of construction adopted in the construction industry is important in term of the production of waste. Some modern type of construction method such as prefabrication method can greatly reduce the waste in construction site as compared to the traditional method.

With the understanding of the factor of material waste produced, it is important to find out the types of material waste created in construction industry. The intention of finding the wastage level for both prefabrication and conventional method is to give a support that the usage of prefabrication method will produce less waste to the environment.

In order to create a healthy and sustainable environment, it is important to adopt a proper planning and construction practice.

1.4 Aim of Study

The aim of this study is to determine the better construction method between conventional and prefabrication in producing less material waste on site.

1.5 Objectives of Study

1. To analyse various types of material wastage in conventional and prefabrication on construction site.
2. To investigate the level of material wastage between conventional and prefabrication construction method.

1.6 Scope and Limitation of the Research

This research is mainly focus on the two types of construction method namely, conventional method and prefabrication method in term of waste production. The research is limited to obtain the opinions by the respondents from the contractor's firms registered under CIDB in Kuala Lumpur only.

1.7 Organization of Each Chapter

A total of 5 chapters will be compiled at the end of this research. 5 chapters included the 'Introduction', 'Literature Review', 'Research Methodology', 'Data Analysis and Finding' and lastly the 'Conclusions and Recommendations'.

In Chapter 1 (Introduction), background of the research will be discussed first, then follow by problem statements by providing the real facts and evidences occur in construction industry in Malaysia. After the importance of study, the aim and objectives of study will be included in this chapter too. Lastly, the scope and limitation of the research were included to narrow down the area of this study.

Chapter 2 is about 'Literature Review', this chapter is focus on the reviewed from other research paper, journal, conference paper, newspaper, books and so on. Firstly, defined all the terms based on the research title. Then the types of construction waste will be discussed here, follow by the factors of construction waste production and lastly compare between conventional method and prefabrication method on the difference waste level.

Next is Chapter 3 about the 'Research Methodology', this chapter discusses the method used to conduct the research from research process, research strategy and research technique. Sample frame and population will be discussed in this chapter. Development of questionnaire and the method of data analysis will be described in details in this chapter.

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Chapter 4 is about the 'Data Analysis and Finding'. This chapter mainly discussed the data obtained from the questionnaire and analyse the data based on data obtained. The questions analysed must reach the objectives of the research.

Lastly, Chapter 5 is the 'Conclusions and Recommendations', in this chapter, the finding's summary will be summarised again to make sure the objectives is achieved. Limitation of study and the future research recommendations will be described in this chapter as well. After that, a brief conclusion is made based on the overall thesis.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is about the literature review. All the literature presented in this chapter are reviewed and referred from the conference papers, journals, research paper, books newspaper and etc. This chapter includes the definition of the terms for the research title, types of construction waste, factors of construction waste generation, material wastage level between conventional construction method and prefabrication construction method.

2.2 Definition of "Construction Waste", "Conventional Construction Method" and "Prefabrication Construction Method"

According to Serpell and Ferguson (1998), "waste is defined as material by product of human and industrial activity that has no residual value".

In this thesis, "waste" is referred to "construction waste". Referring to Tam *et al.*, (2005), construction wastes are in the forms of building debris, rubble, earth, concrete, steel, timber, and mixed site clearance materials, arising from various construction activities including land excavation or formation, civil and building construction, site clearance, demolition activities, roadwork, and building renovation.

There are two major components for the conventional building system namely the structural system and non-structural infill material. Structural system is the cast in-situ frames, while non-structural infill material includes the bricks and plastering (Kadir *et al.*, 2006).

In this thesis, "conventional construction method" is also referring to "traditional construction method". This type of construction method basically involved the concrete, steel reinforcement and timber formwork which are performed on construction site or known as cast in-situ. Most of the structures are built of reinforced concrete.

Prefabrication construction method can be classified into two main categories, namely on-site prefabricated and off-site prefabricated (factory produced). On-site prefabricated method involves casting structural building elements within site before erecting to actual location. On-site pre-casting provides several advantages over cast in-situ construction which includes the mass production of units, cost and time reduction and improved quality of work. Off-site prefabricated method involves transferring building operations from site to factory. Prefabrication allows a component to be built whenever convenient, as long as it is delivered on time (Badir and Razali, 1998).

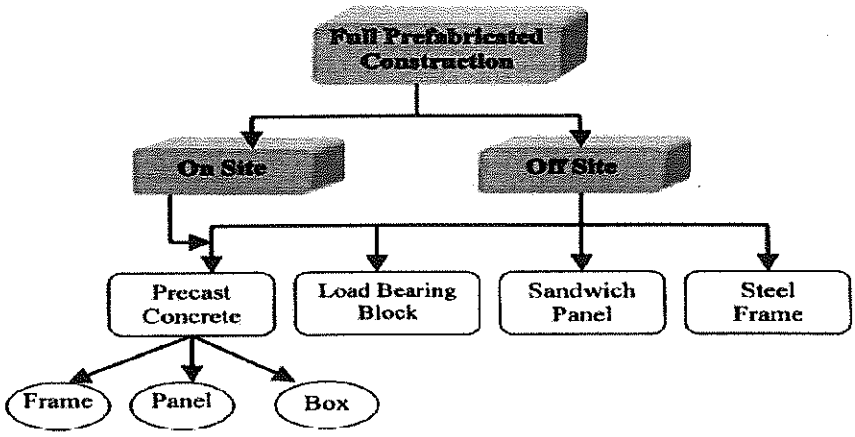

Figure 2.1: Classification of fully prefabricated construction method. (Badir and Razali, 1998)

According to Tam, Tam and Ng (2007), prefabricated building components are divided into 3 categories, namely 'semi-prefabrication" which are the non-structural prefabrication applications like curtain wall, 'comprehensive prefabrication' are the structural applications such as staircase and 'modular building' which is refer to a 'one-stop' system and including all the finished.

For prefabrication construction method, it is either casting the components on site or in factory before delivers it to the construction site. Conventional construction method is time consuming if compared with this construction method.

2.3 Types of Construction Waste

There are many types of construction waste. Many studies have been conducted regarding the construction waste. Among so many types of waste, concrete, cement, aggregate, block, tile, timber are mostly wasted on construction site (Bossink and Brouwers, 1996; Formoso *et al.*, 2002; Shen *et al.*, 2002; Poon *et al.*, 2004).

2.3.1 Concrete

There are 2 types of concrete namely ready-mixed and site mixed. Ready-mixed concrete are usually produced in the factory and then deliver to construction site. Site mixed are usually hand-mixed by the workers on construction site. Nowadays, most of the works such as sub-structure and super-structure are using ready-mixed concrete as it is time saving.

Based on Poon *et al.* (2004), a survey of 22 construction sites in Hong Kong, 80% of the work was made from ready mixed concrete. On average, 3% to 5% of the concrete was wasted by over ordering of material, broken formwork and reconstruct due to poor concrete placement quality.

McDonald and Smithers (1998) discovered that 6.7% of the concrete wastes were obtained after pouring. The wasted concrete was then crushed by the crushing machine and used as road base when constructing the road.

According to Formoso *et al.* (2002), the researchers discovered that a total 64% of the construction site has ignored the issue of concrete waste. Site managers claimed that it is hard for them to control such waste on construction site. Apart from this, the researchers found out that inadequate of machinery or plant and the site layout problem caused the waste of concrete too.

In addition, the researcher also mentioned that the "lack of proper planning and poor estimation usually caused the contractors of over ordering and overfilled into the formwork". If the formwork is overloaded, it is essential to carry out skimming (Bossink and Brouwers, 1996).

Concrete waste is a very common issue happened in construction industry. Most of the concrete wastes are due to the broken or defective formwork, poor estimation for the ordering and poor quality supplied from supplier.

2.3.2 Timber Formwork

Timber formwork can be used in either permanent or temporary as the mould for concrete in order to construct a structure. If timber formwork as a permanent moulds, it will be remained with the structure when the concrete is cured. It will be stripped-off if it is used as temporary mould for concrete to form a structure.

Referring to Shen *et al.* (2002), timber board is a major material used in construction site. Natural deterioration resulting from usage and cutting waste are the main causes of timber wastage. Both of it are difficult to avoid.

In Hong Kong, the great contributor of waste in construction industry is timber formwork. Based on Poon *et al.* (2004), cutting timber for internal finishing and fittings may become the mainstream of the timber waste which is generated from the formwork with a smaller quantity.

Timber formwork is generally low in durability. It can be warp and become defective after exposing to the rain water. Timber formwork is low in reusability too. After several time of reuses, it will be discarded on the construction site and become waste.

2.3.3 Steel Reinforcement

Steel reinforcement bars are one of the frequently used materials during the construction of building. The main cause of steel wastage is resulted from cutting. Damages and rusting during storage also forms a major part of steel wastage (Tam, Shen and Tam, 2007; Shen *et al.*, 2002).

Based on Formoso *et al.* (2002), "steel reinforcement wastes are usually from the short and unusable pieces, the size of the bar manufactured is too large and stolen by the trespasser".

Steel reinforcement wastage can be concluded as most of the steel reinforcement waste is from cutting, rusting and damaging due to incorrect way of storing. This is because steel reinforcement bar will get corrosion easily if it is stored in a high humidity area.

2.3.4 Cement

Cement is a material usually mixed with water and sand to form the mortar. Generally, after ther mixture of cement with water and sand, it can be used as brickwalls mortars, plastering to the wall or ceiling, and as the screed for flooring.

Bossink and Brouwers (1996) pointed that mortar is used to set stone tablets and sand-lime bricks as well as to finish off the facings of the buildings.

Formoso *et al.* (2002) had stated the five main sources of waste which are in-situ production of mortar, handling and transportation of mortar, brickwork joint, plaster thickness and floor screed. Further explanations are as following:

i. In-situ production of mortar - lack of information in producing different mixes of mortar

ii. Handling & transportation of mortar – due to site layout problems, and insufficient equipment.

iii. Brickwork joint is usually a combination of reasons for the excessive thickness of joints, which may include lack of modular coordination between concrete structure and brick walls, inadequate training of labour, insufficient information available about process standards, inadequate supervision, variations in the size of blocks, and lack of process standardisation.

iv. Plaster thickness – lack of modular coordination in design and omission of the design

v. Floor screed - deviated in the concrete slab level in relation to design and inlay pipes in the floor.

To conclude, the lack of information for any details thickness and handling and transporting of cement and mortar are the major factor of cement and mortar waste generation.

2.3.5 Aggregate

Concrete can be site-mixed by using the mixture of water, sand and aggregate. Based on Formoso *et al.* (2002), there are two types of aggregate namely fine aggregate and coarse aggregate. The waste of aggregate usually created from the cement mortar and concrete. The waste of the concrete and cement mortar will certainly cause the wastage of aggregate too.

2.3.6 Bricks and Blocks

Bricks and blocks are the most common walling materials. The main cause of these wastes is by cutting. In the case of unpacked supply, wastage can also be generated due to damages to theses fragile materials. Besides that, unused bricks left on site may end up in the trash skip ultimately and such wastes can be significant in those projects where materials planning are poor (Shen *et al.*, 2002; Tam, Shen and Tam, 2007).

Referring to Formoso *et al.* (2002), "the causes related to bricks and blocks included the poor internal handling and transportation, excessive cutting, labour mistakes, flow activities and conversion activities".

As a conclusion, bricks and blocks wastage is usually generated cause by cutting due to lack of modular coordination, damaging and broken during handling and loading of materials.

2.3.7 Tiles

According to Tam, Shen and Tam (2007), tiles are normally wasted in a non-consequent process, affected by different stages of construction sequences. Poor coordination and communication may result the sizes of the materials not match as what specified in the design. Sometimes, wastes have to occur in the application to these specific sized areas.

Referring to Formoso *et al.* (2002), improper modular coordination between the structural and architecture design will caused the cutting waste of a tile. Improper planning during the delivery of materials will cause the waste generation too.

As mentioned by Bossink and Brouwers (1996), the dimension of the roof tile is important. Mistreated the size or dimension of the roof tile will caused the waste by sawing. Late information obtained by the contractors on the specifications and the size used during construction and broken tiles during the delivering process are known as the cause waste generated from tiles.

As a conclusion, lack of modular coordination, late announcement to the contractors, lack of knowledge by the designer, breakage during delivering process are the main factors which cause waste on tiles.

2.3.8 Pipes and Wires

According to Formoso *et al.* (2002), most of the electrical and plumbing services are under subcontractor's work. As this activity is often very scattered, such materials are often moved in and out of the construction site. Besides that, the difficulty related to the measurement of waste is the fact that both plumbing and electrical service designs are often lack of detailed, and many changes in the routings of pipes are made during the installation. The most important causes of waste for these materials are short unusable pieces produced when pipes are cut; poor planning in the distribution of materials, which does not encourage cutting optimization; and replacement of elements by others that have superior performance.