AN INVESTIGATION ON THE CONSTRUCTION WASTE GENERATION RATE IN MALAYSIA BASED ON DIFFERENT TYPES OF PROJECTS

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DEDICATION

To my lovely mother and father, who gave me endless love, trust, constant encouragement over the years, and for their prayers.

To my friends, who gave me moral support in all forms, love, and prayers.

This thesis is dedicated to them.

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ABSTRACT

Urban areas in Malaysia are growing rapidly which lead to construction and demolition (C&D) waste generation to expanding significantly due to many new developments throughout the country. In Malaysian construction industry, the most crucial issue highlighted by researchers and mass media is the excessiveness of C&D waste generation. The dumping of C&D waste at landfills has realized major ecological concerns and government sources demonstrate that landfill spaces in Malaysia are diminishing. The aim of this study is to investigate the construction waste generation rate in Malaysia due to different construction project types. To obtain the waste generation rate, construction sites visit is required. In the construction site, direct and indirect approaches were utilized to collect C&D waste generation data depending on accessible information. The findings show that non-residential projects obtained the lowest Waste Generation Rate (WGR) such as 0.008 t/m^2 compared to other types of projects. Meanwhile, social amenities projects produced very less construction waste such as 30.73 tons compared to residential and non-residential projects. This study will be very beneficial for contractors and clients to control the construction waste in the construction site and to recognize efficiencies of undertaking waste generation rate in the site. Other than that, it provides a generation rate on construction waste for the government to implement the law in controlling waste and reducing illegal dumping in the future.

ABSTRAK

Malaysia adalah negara yang mempunyai pembangunan pesat di pusat-pusat bandar di mana penjanaan sisa pembinaan dan perobohan telah meningkat dengan perkembangan industri pembinaan baru. Di Malaysia, isu paling penting yang ditonjolkan oleh para penyelidik dan media massa adalah terlalu banyak penjanaan sisa pembinaan dan pencerobohan. Penghantaran sisa pembinaan dan perobohan ke tapak pelupusan telah membawa kebimbangan ekologi dan juga sumber kerajaan menunjukkan bahawa terdapat kekurangan ruang tapak pelupusan di Malaysia. Tujuan kajian ini adalah untuk menyiasat kadar penjanaan sisa pembinaan di Malaysia untuk jenis projek yang berlainan. Lawatan tapak pembinaan diperlukan untuk mendapatkan kadar penjanaan sisa. Di tapak pembinaan, kaedah secara langsung *(direct)* dan tidak langsung *(indirect)* telah digunakan untuk mengumpul data penjanaan sisa berdasarkan data yang ada. Daripada kajian ini, projek bukan kediaman memperolehi kadar generasi sisa terendah iaitu 0.008 t/m^2 berbanding dengan jenis projek lain. Selain itu, projek-projek kemudahan sosial menghasilkan sisa pembinaan yang kurang iaitu 30.73 ton berbanding dengan projek kediaman dan bukan kediaman. Kajian ini sangat bermanfaat bagi kontraktor dan pelanggan untuk mengawal sisa pembinaan di tapak pembinaan dan juga untuk mengenal pasti kebaikan projek dengan menggunakan kadar penjanaan sisa. Selain itu, kadar penjanaan sisa pembinaan memberi keuntungan kepada Kerajaan bagi mengawal sisa dan mengurangkan pembuangan haram pada masa akan datang.

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LIST OF SYMBOLS & ABBREAVIATIONS

CIDB - Construction Industry Development Board

CW - Construction Waste

C&D - Construction and Demolition

WGR - Waste Generation Rate

AWGR - Average Waste Generation Rate

GFA - Gross Floor Area

IBS - Industrialized Building System

GFA - Gross Floor Area

SV - Site Visit

FM - Field Measurement

GRC - Generation Rate Classification

CSA - Classification System Accumulation

MSW - Municipal Solid Waste

DO - Delivery orders

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CHAPTER 1

INTRODUCTION

1.1 Background

Construction and demolition waste is a constraining issue not just in Malaysia but also in other developing countries. Malaysia has a rapid development of its urban centers in which construction and demolition (C&D) waste generation is increasing proportionately with the new construction industry development (Domingo & Batty, 2021). The construction industry is a quick developing industry influenced by the increment in the way of life, demands of infrastructure projects, changes in utilization propensities, and additionally regular increment in population. C&D waste is all waste produced from construction and demolition activities (Mah & Fujiwara, 2016).

Different types of C&D waste are produced in construction and demolition site. Typical components in C&D waste include inert materials (e.g., concrete, metal, etc.). Construction wastes are normally produced due to construction, demolition, renovation, real estate development, infrastructure construction, earthworks, and land clearing operation. There are some types of waste such as concrete, metal, brick, drywall, roofing, material packaging, plastics, papers, cardboard and others (Umar & Syafiq, 2021). C&D waste should be overseen all through the construction period (Reza & Rigamonti, 2016).

This construction has contributed altogether in the waste generation which has turned out to be a serious issue for every country (Nagapan & Rahman, 2012). In Hong Kong, from 1993 to 2004, the yearly generation of C&D waste has dramatically increased, which achieved a measure of 20 million tons in 2004 for a single year (Wang & Pan, 2021).

Arrangement of construction waste is a review into the structure and measure of construction waste generation, classification upgrades comprehension of the sources and reasons for waste generation. The meaning of construction waste differs and depends fundamentally on the sort of construction and practices where the testing is performed (Tang & Bunrith, 2021).

In Malaysia, there is exceptionally restricted study being directed on the issue of construction waste. Thus, there is not much information accessible on the present structure of construction waste streams by the source of generation, sort of waste, the measure of raisings produced and arranged, and the measure of waste reduced, recycled or reused (Kabirifar & Vivian, 2008). The secondary study is conducted here to find comprehensive data available regarding the amount of construction waste generation and waste generation rate for available types of projects in Malaysia.

1.2 Problem Statement

Nowadays, construction industry is engaged with several difficult problems like producing substantial construction waste, cost, project delay, safety issue and poor internal control (Hoang *et al*., 2020). However, in Malaysia, C&D waste generation is also considered as the most crucial issue (Nagapan, Rahman & Asmi, 2012; Nurzalikha & Zulhabri, 2015) because a significant portion of waste produced by construction activities poses serious environmental concern which is finally disposed into the landfills (Sin *et al*., 2013). The illegal dumping of concrete waste into the landfills creates serious concern (Hoang *et al*., 2020). Furthermore, the transfer of C&D waste to landfills has caused major environmental concerns and government sources have shown that there is an intense lack of landfill space in Malaysia (Vasudevan, 2015). In addition to that, the pollution-induced by building waste creates adverse environmental impacts and leads to economic losses (Sin *et al.,* 2013). Therefore, the construction industry requires immediate attention to decrease construction waste efficiently, to maintain landfill ability and to help obtain the idea of sustainability in the waste building (Sin *et al.,* 2013).

Estimating the waste generation rate may serve as a useful indicator to the waste generation reduction benefits (Mah *et al.,* 2016). According to Mohammed *et*

al. (2021), the amount of construction waste generation varies and depending on the type of project. These types of projects take an important role in measuring the construction waste. Unfortunately, there is no accessible information with respect to the generation rate of construction waste in Malaysia as compared to other nations which have a particular consistent benchmark on construction waste (Mah & Ho, 2016). Therefore, this study is intended to investigate the construction waste generation and waste generation rate in Malaysia according to all types of projects.

1.3 Study Questions

Based on the problem statement, the study questions are formulated as follows:

1) What are the major types of projects in the Malaysian construction industry?
2) How much is the construction waste generation for each type of project?
3) How does the generation rate vary between project types?

1.4 Study Aim and Objectives

The aim of this study is to investigate the construction waste generation rate in Malaysia due to different project types. To achieve this aim, the objectives of this study are:

1) To identify major project types in Malaysian construction industry.
2) To quantify construction waste generation for each type of the project.
3) To establish construction waste generation rate towards the different types of projects.

1.5 Study Scope

This study was conducted in selected construction sites in northern side of Malaysia. The selection of construction sites depended on the permission given site and the availability of construction waste data. The criterion of the site was categorized into construction stage project and the method of construction was conventional method. The targeted construction waste has six major wastes which are concrete and

masonry waste, steel, timber and wood, packaging waste, ceramic and tiles, and others for all types of projects in Malaysia. Construction waste depends on site availability. The gathering of data involved direct and indirect methods based on the data available on the construction site.

1.6 Significance of the study

From the outcome of this study, the generation rate of all types of projects is determined. It will be beneficial for contractors and clients to estimate and control their construction waste at the site. This finding will indirectly reduce illegal dumping problem because the site personnel are able to predict the waste generated during the project period. This study brings measurable data for the allocation of resources in future project planning, material supply, and waste management for the development project. Moreover, this study disseminates to all parties involved in construction with a view towards widespread use in future construction waste estimation and minimization such as Construction Industry Development Board Malaysia (CIDB) which is presently running Construction Industry Transformation Program (CITP) for sustainable construction in Malaysia.

1.7 Structure of thesis

This thesis is divided into five chapters as follows:

Chapter 1: This chapter describes the need of this study. It contains study background, problem statements, objectives, scopes of study, research methodology, and structure of thesis.

Chapter 2: This chapter elaborates on related literature through the published research work. It includes the definition, classification, methods and cause of construction and demolition waste. Methods used by past researchers were highlighted in this chapter. Waste Generation Rate which focused on this research were highlighted and elaborated according to past researchers and research.

Chapter 3: This chapter describes how this research is carried out. It explains the technique of data collection and the way to analyze them. The technique was adopted by past researchers. Site measurement techniques were used to collect data. Direct and indirect data collection were conducted. Collected data were analyzed using proper guidance and Microsoft excel tools were used.

Chapter 4: The collected and calculated data will be illustrated in this chapter. It includes data calculation methods and average data for every type of project. Waste generation rates were identified for every project and also every type of projects.

Chapter 5: This chapter presents the conclusion of the study. It also presents some recommendations for future study and limitations that arise while this study was conducted.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter contains literature review regarding construction and demolition waste and their issues and common types involved in construction progress. This chapter also includes construction and demolition waste (C&D) issues and management in Malaysia and other countries. This review helps to expand knowledge on construction and demolition waste and most importantly for achieving the objectives of this study.

2.2 Definition of construction and demolition waste

Construction waste materials comprise of garbage created during the construction, renovation, and demolition activity of roads, buildings, bridges, and other related works. Construction waste materials regularly contain massive, overwhelming materials that incorporate concrete, wood, steel, bricks, glass, plastics, trees, asphalt, and rock from clearing sites (Nguyen, 2021). As mentioned by Ghafourian and Abolghasemi (2016), the term Construction and Demolition waste is identified with a strong waste generation that is predominant in the construction and building area. Furthermore, Construction and Demolition (C&D) Waste described the waste that was produced through construction activities like renovation, demolition, excavation, site cleanses, etc. (Mohammed, 2021).

C&D waste or debris could be utilized as recycled material in the construction of structures and roads. Residential and commercial construction and demolition waste incorporate materials produced in the construction, remodel, or

annihilation of houses, lofts, office structures, or comparative structures. This likewise incorporates bundling and other unexpected materials identified with a building construction project (Dajadian & Koch, 2014).

In the United States, C&D waste is a waste material that is "delivered during the process of construction, redesign, or demolition of structures. Structures incorporate structures of various kinds (both residential and non-residential) and in addition roads and bridges. Segments of C&D debris normally incorporate concrete, asphalt, wood, metals, gypsum wallboard, and roofing" (Zhao *et al*., 2010). C&D waste is characterized as the surplus and harmed items and materials that emerge from construction, redesign, destruction, and other construction exercises. In a few settings, 'C&D waste' and 'construction waste' are utilized conversely for effortlessness, or when the waste sources are not the focus (Wang & Pan, 2017).

Normally, construction waste may comprise dangerous material which may influence people and surroundings. However, hazardous waste is generally produced during construction activities which involves paints, solvents, adhesives, pesticides, oil, or stored materials that have exceeded their shelf life (Hassan *et al*., 2012). Therefore, construction waste is considered a serious issue in urban communities around the world (Domingo *et al*., 2021). As indicated by statistical data, C&D garbage received at numerous landfill sites in the range of 10 to 30% of total waste (Hassan *et al*., 2012). Hence, the definition of C&D waste can be concluded as waste or debris produced from construction and demolition activities and all work related to civil and construction engineering.

2.3 Classification of construction and demolition waste

Construction waste can be bunched into two groups which are physical and non-physical waste. Physical waste is produced as material. It adds to a huge piece of landfill. On the other hand, non-physical construction waste includes time and cost overrun for construction projects. These issues will turn out to be more critical when there is a stoppage of specific construction work and this causes the discontinue of the project (Nagapan, Hameed & Zin, 2012).

To satisfactorily measure the construction waste, it is valuable to have an order of waste by source and type of waste produced (Raju Ponnada, 2015). There

are numerous sources of waste generation in construction sites. The following are the main waste produced from construction activities:

a) Timber and Wood

Waste materials that are predominately new wood from new construction. This may include plywood, chip wood, dimensional lumber and sawdust (Raju Ponnada, 2015). Figure 2.1 shows the example of timber waste from the construction site.

Figure 2.1: Wood Waste at construction site

b) Metals

Metallic materials are waste products of new construction. This material consists of new metal studs and metal beams and pipes (Coelho & De Brito, 2012). Figure 2.2 shows an example of metal waste from the construction site.

Figure 2.2: Metal Waste at construction site

c) Mineral debris

Mineral debris consists of stone, bricks, mortar and concrete waste from construction site (Cochran & Townsend, 2010). Figure 2.3 shows an example of mineral debris from a construction site.

Figure 2.3: Mineral Debris at construction and demolition site

d) Plastics

Plastic waste materials are used in new construction. This includes PVC plumbing pipe, PVC siding, Styrofoam insulation, and plastic sheet (Raju Ponnada, 2015). Figure 2.4 shows an example of plastics waste from the construction site.

Figure 2.4: Plastics Waste at construction site

e) Paper and cardboard

Paper and cardboard wastes include cardboard boxes, boxboard, and cardboard packing material (de Guzmán Báez *et al.*, 2012). Figure 2.5 shows examples of cardboard waste from the construction site.

Figure 2.5: Cardboard Waste at construction site

f) Glass

Glass waste consists of glass material used to decorate the constructed buildings (Raju Ponnada, 2015). Figure 2.6 shows an example of glass waste produced from construction.

Figure 2.6: Glass Waste at construction site

g) Ceramic and Tiles

Ceramic and tile wastes are left and wasted from the construction site (Sin *et al.*, 2013). Figure 2.7 shows an example of glass waste produced from construction.

Figure 2.7: Ceramic and Tile Wastes construction site

h) Others

Any waste materials originating from new construction which do not fit into one of the categories mentioned earlier are considered as mix waste (Sin *et al.*, 2013). Figure 2.8 shows the example of mix waste produced from construction.

Figure 2.8: Mix Waste at construction waste

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