MODELLING A MISHANDLING MATERIAL OCCURRENCE OF CONSTRUCTION WASTE AT KLANG VALLEY'S CONSTRUCTION PROJECTS

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ABSTRACT

Construction waste generation is one of the main issues that results from rapid development in Malaysian construction industry. To reduce the waste produced by construction projects, it is important to rectify the causes of construction waste generation. According to previous studies, mishandling of construction materials has been one of the key factors that lead to construction waste generation. Therefore, this research aims to develop a structural relationship model of mishandling material in Malaysian construction industry. The quantitative approach, through a structured questionnaire survey is used to verify the root causes of mishandling material to determine the mishandling material occurrence. A total of 218 valid questionnaire responses were accounted and found 36 root causes of mishandling materials in total. Next, the root causes have been grouped using factor analysis which resulted to 5 groups of root causes namely Material and Procurement, On-Site Operation, Site Management and Practices, Human Resource, and Transportation. Then, the structural model of mishandling material was established using the multivariate approach of Partial Least Square-Structural Equation Modelling (PLS-SEM). The model indicates that Human Resource Group has the highest impact on the mishandling material occurrence with a path coefficient value of 0.226. The findings revealed the top three root causes of mishandling materials which are ‘Unnecessary material handling on site’, ‘Carelessness of workers, and followed by ‘High usage of manual labour in material handling’. In addition, the model was validated by construction experts where’s 92% of them agreed with the findings. Thus, the model has the potential to educate construction practitioners to minimize the mishandling of material in order to reduce waste generation by focusing on the established root causes to solve the particular issue in the construction industry.

ABSTRAK

Penjanaan sisa pembinaan adalah salah satu isu yang utama, terhasil daripada pembangunan pesat dalam industri pembinaan di Malaysia. Pengenalpastian punca adalah penting bagi mengurangkan penjanaan sisa pembinaan. Menurut kajian lepas, pengendalian bahan binaan menjadi salah satu faktor utama yang membawa kepada penjanaan sisa pembinaan. Oleh itu, kajian ini bertujuan bagi membangunkan model struktur bagi salah pengendalian bahan dalam industri pembinaan Malaysia. Pendekatan kuantitatif digunakan melalui tinjauan soal selidik berstruktur untuk mengesahkan punca dan menentukan kejadian salah pengendalian bahan. Sebanyak 218 borang soal selidik yang sah telah diambil kira dan mendapati 36 punca salah guna bahan secara keseluruhannya. Seterusnya, punca-punca tersebut dikategorikan menggunakan kaedah faktor analisis dan menghasilkan 5 kumpulan iaitu Bahan dan Perolehan, Operasi di Tapak, Pengurusan dan Amalan Tapak, Sumber Manusia dan Pengangkutan. Kemudian, model struktur salah pengendalian bahan telah diwujudkan menggunakan pendekatan multivariat *Partial Least Square-Structural Equation Modelling* (PLS-SEM). Model ini menunjukkan bahawa Kumpulan Sumber Manusia mempunyai kesan yang paling tinggi terhadap kejadian salah pengendalian bahan dengan nilai pekali laluan 0.226. Penemuan itu mendedahkan tiga punca utama salah pengendalian bahan iaitu ‘Pengendalian bahan yang tidak perlu di tapak’, ‘Kecuaian pekerja’ dan diikuti dengan ‘Penggunaan buruh yang tinggi secara manual dalam pengendalian bahan’. Tambahan lagi, model tersebut telah disahkan oleh pakar pembinaan di mana 92% daripada mereka telah bersetuju dengan penemuan tersebut. Oleh itu, model ini berpotensi untuk mendidik pengamal pembinaan untuk meminimumkan kesalahan pengendalian bahan bagi mengurangkan penjanaan sisa dengan memberi tumpuan kepada punca yang telah ditetapkan untuk menyelesaikan isu tertentu dalam industri pembinaan.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Construction waste generation is a pressing issue in many countries, including Malaysia. According to Luangcharoenrat *et al*., (2019), waste from construction indicates all construction materials that cannot be reused, which includes leftover construction materials and damaged materials that accumulate while working or through improper handling. Construction waste also refers to unwanted substances that are produced during the construction phase and renovation of structures (Yeheyis *et al*., 2016). In addition, the previous researcher mentioned that construction waste includes construction fragments, ruins, disasters, construction materials, building construction and demolition, site clearance, and any type of waste from construction activities (Shen *et al*., 2017). In this study, construction waste can also be defined as an unused resource of materials and equipment involving time and human resources, initially designed for one purpose that brings harm to the environment or is abandoned without initiating any plan of utilisation or recovery.

The classification of construction waste was primarily based on the philosophies of lean construction, which are divided into three groups that contain nineteen factors (Koskela, 1997; Serpell *et al*., 1995; Alarcon, 1994 & 1995; Womack & Jones, 1996; Formoso *et al*., 1999, 2002). They are described as direct construction waste that derives from materials, manpower, and equipment when performing an activity; non-contributory time waste that pertains to time for waiting, travelling, and idling; and contributory time waste that pertains to time for supervision, transport, inspection, instruction, and communication.

Moreover, construction waste is defined as waste that is derived from construction, renovation, and demolition activities, including land excavation or formation, civil and building construction, site clearance, demolition activities, roadwork, and building renovation. Some, however, define solid waste as inert waste, which comprises primarily sand, bricks, blocks, steel, concrete debris, tiles, bamboo, plastics, glass, wood, paper, vegetation, and other organic materials. This type of waste is usually removed from the site and disposed of in landfills. This type of waste consists of a complete loss of materials since they are irreparably damaged or simply lost (Rahman & Janagan, 2015). Material waste that has been increasing on sites harms the ecosystem.

Thus, a rising on a construction waste gives harmful impact to the eco-system and it is one of the main issues in Malaysian construction industry (Begum *et al*., 2010; CIDB, 2019). Therefore, the Malaysian government has implemented the Construction Industry Development Board (CIDB) Strategic Plan for five years from 2021–2025, and one of the main objectives is to reduce the negative impact on the environment derived from the construction industry (CIDB, 2019).

Furthermore, Narcis *et al*., (2019) and Ayegba (2013) discovered that the primary causes of construction waste on construction sites are damage from improper material handling. Mishandling material is defined as the outcome of improper work procedures for the reception of goods, an inadequate storage space plan, and a failure to provide adequate storage space and adequate handling resources and methods, taking into account a variety of factors, including means of access (Hung & Kamaludin, 2017). Moreover, when contractors handle fragile materials, such as bricks, tiles, and glass incorrectly, they can easily break them, resulting in waste. Therefore, it is very important to handle construction materials carefully to avoid waste.

In contrast, proper construction material handling during construction activity reduces the generation of construction waste. Efficient material management can result in significant reserve funds for project costs. Thus, material management is an important aspect of project management. Materials on a task can represent anywhere from half to 60% of the work expense, so limiting procurement costs opens the door to lowering overall project costs. Poor material management expands the expenses during construction (Raj & Sai, 2019).

According to Ekanayake and Ofori (2000), many factors contribute to the generation of waste material, but these factors can be grouped into four main categories: design, procurement, operation, and handling of materials. Most of the materials at construction sites are handled by contractors (workers). As a result, the greater the number of unskilled construction workers, the more waste they generate. There are many causes of mishandling materials by contractors, and it is important to identify the causes to minimise construction waste accordingly.

In general, construction waste generation is possible in every phase of construction if construction practitioners are not concerned (Begum *et al*., 2010). More than that, it is important to educate the contractors about material handling to avoid the waste generated from mishandling material (Kaliannan *et al*., 2018; Akhund *et al*., 2019; Yadeta & Eshetie, 2019).

1.2 Problem Statement

Ford (1927) and Hyginus *et al.*, (2020) pointed out that human work should be the focus of waste prevention, since the value of materials depends on the work that we are handling, likely mishandling materials due to human errors is a main issue that contributes to construction waste. It proves that mishandling material is one of the main issues that occurs for decades in construction industry.

Primarily, mishandling of construction materials leads to massive construction waste generation as supported by many researchers (Raja *et al*., 2019; Tedla & Patel (2018); Jein *et al*., 2018; Luangcharoenrat *et al*., 2019; Ugochukwu *et al*., 2017; Yadeta & Eshetie, 2019). Likely, a massive waste about 40% is produced globally due to construction activities (Rahim *et al*., 2017; Sharma *et al.*, 2011). Additionally, about 25 600 tonnes of construction waste produced every day (Saadi *et al*., 2016, Wong & Roslan, 2019, Kupusamy *et al*., 2019). Construction waste has been perceived as one of the highly generating waste in Malaysia (Esin & Cosgun, 2007; Omeje *et al*., 2020).

Furthermore, this huge waste that derives from mishandling material can cause an impact on eco-system. Precisely, it contributes to many environmental problems such as illegal dumping, pollution, and health issues (Coen-Pirani *et al*., 2018). Illegal dumping activity is bad for the environment nor it effects the economy and also social (Rahim *et al*., 2017). The illegal dumping problems that often occurs in Malaysia reveals that our country needs more attention in handling the material at construction

sites. Exactly, about 851 of illegal dumping area has been discovered by SWCorp Malaysia and it has to be focused on even more often in order to reduce the construction waste generation in Malaysia (Rahim *et al*., (2017). Probably, these illegal dumping activities are often occurs when the workers wrongly handle the construction materials that results to a massive waste production from various construction activities.

Moreover, mishandling material tends to accelerate the cost overrun and time overrun issues in construction projects (Durdyev *et al*., 2017; Vaardini *et al*., 2016; Enshassi *et al*., 2010). Cost overrun defined as an excess of actual cost over standardized budget. When the contractors wrongly handle the material, it become a waste. Therefore, company had to re-order the material if it exceeds the stock/ number of ordered materials. These additional materials require to complete that particular construction project as scheduled. Obviously, it leads to double work which requires more time and money. Thus, it can lead to some delay in projects and cost overrun.

In addition to that, to reduce the generation of construction waste, the government have also targeted for zero waste. Figure 1.1 shows an article about aiming for zero construction waste by 2030.

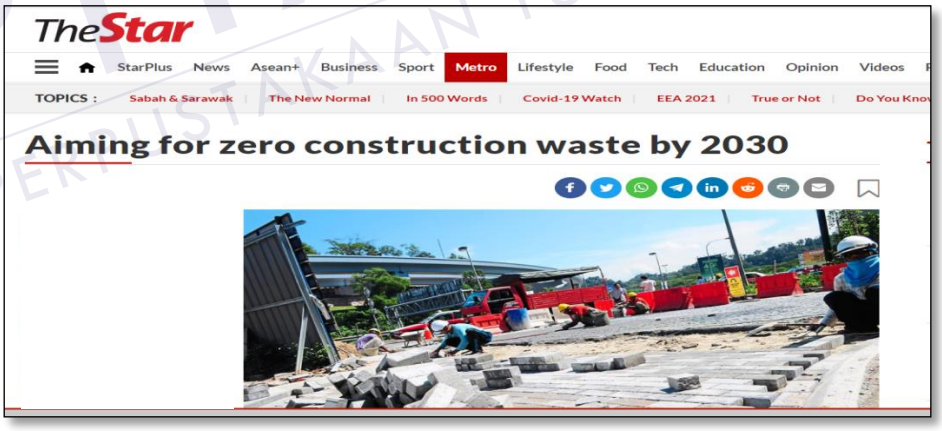

Figure 1.1: Zero Construction Waste by 2030 (Chen, 2015)

However, there are very less researches and studies discovered about mishandling of construction materials in Malaysia. Ikau *et al*., (2016), also describes that mishandling material leads to construction waste generation. Hence, it is important to identify and explore more on the causes of mishandling material at construction sites (Omeja *et al*., 2020; Nikmehr *et al*., 2015; Yadeta & Eshetie, 2019; Whyte *et al*., 2018;

Raja *et al*., 2019; Luangcharoenrat *et al*., 2019, Polat *et al*., 2017). Mishandling materials refers to the wrong handling of materials that occurs during various construction activities. When the contractors mishandle the construction materials, it tends to break or damage easily. For an example, tiles can be broken if handle it in hard way and concrete can be damaged if store it in a wet area or as expose in rainwater if placing under open area.

Therefore, a model of the causes of mishandling materials is helpful to enhance awareness among construction workers in Malaysia. This study will also contribute knowledge to the body of construction waste management by identifying the significant root causes of mishandling material.

1.3 Research questions

The research questions are developed to assist the researcher in achieving the objectives based on the problem statement of this research. The research questions are as follows:

i. What are the root causes of mishandling materials at construction sites?

ii. What are the significant root causes of mishandling materials in the Malaysian construction industry?

iii. What is the appropriate model that can be developed for the root causes of mishandling material towards mishandling of construction material?

1.4 Aim and Objectives

The purpose of this research is to identify the root causes of mishandling material and its occurrence at construction sites. To achieve this aim, the objectives are developed as below:

i. To identify the root causes of mishandling materials at construction sites.
ii. To determine the significant root causes of mishandling materials at construction sites.

iii. To develop a structural model of the root causes of mishandling materials at construction sites.

1.5 Scope of research

This study focused on the mishandling of materials during the construction phase in Klang Valley (Selangor and Kuala Lumpur). A structured questionnaire survey conducted to conduct this research among contractors. The main causes of material mishandling were determined using a quantitative methodology via a questionnaire survey. The respondents to this study are focused on contractors who work on-site projects. All the questionnaires dispersed throughout Klang Valley which is Kuala Lumpur and Selangor, as most of the construction projects are developing there. The collected data analysed using SPSS and SmartPLS software.

1.6 Significance of research

All over the world, the waste that is generated during the construction industry phase is unavoidable, and no construction site is zero-waste. Moreover, construction waste generation rate has been increasing from year to year. In that case, mishandling materials by the contractors (workers) on-site emerged as one of the factors contributing to construction material waste generation at most of the construction sites.

Therefore, it is vital to identify the root causes of mishandling material to reduce the massive waste generation during construction activities. Based on the previous researcher's findings, mishandling material has become one of the important causes of material waste generation that should be underlined. In general, this study is useful in identifying the root causes of mishandling materials and how mishandling materials factors affect construction waste generated each year. Finding the root causes of mishandling materials by contractors at construction sites is prudent for construction firms and will also be helpful in reducing waste generation in the future.

1.7 Organization of study

The organization of each chapter in the thesis described below:-

i. Chapter 1: Introduction - This chapter converses the background of the research with describing the current scenario, problem statement, objectives and scope of this study. It also emphasize on the contribution of this study. This study also formed a hypothesis to be discussed (Table 1.1).

ii. Chapter 2: Literature Review - This chapter elaborates, and discusses the previous studies done by other researchers focusing on the root causes of mishandling material on site.

iii. Chapter 3: Research Methodology - This chapter demonstrates the flow and method of research initially from the planning, until the implementation used, related standards and previous literature guidelines on the quantitative studies.

iv. Chapter 4: Data Analysis and Discussion - This chapter comprises of overall result and discussions about the root causes of mishandling material at construction projects in Klang Valley. The obtained data is analysed through SPSS.

v. Chapter 5: Structural Equation Modelling - A mishandling material model was developed using the PLS-SEM approach and the output discussed in this chapter. The mishandling material model was developed for a better understanding of the construction practitioners and verified and validate by the construction experts.

vi. Chapter 6: Conclusions and Recommendations - This chapter concludes the study with recommendations and contribution to the body of knowledge as well as to the construction industry.

1.8 Conclusion

Construction waste has been recognised as a major problem in the construction industry that has important implications both for the efficiency industry and the impact of construction projects on the environment. The study about the root causes of mishandling materials was carried out in Klang Valley and described in this research. In addition, there are 5 hypotheses formed in the study to achieve the objective of the study as in Table 1.1.

Table 1.1: Description of the hypothesis

H1	Root Cause 1 has significant effect to overall mishandling of materials
H2	Root Cause 2 has significant effect to overall mishandling of materials
H3	Root Cause 3 has significant effect to overall mishandling of materials
H4	Root Cause 4 has significant effect to overall mishandling of materials
H5	Root Cause 5 has significant effect to overall mishandling of materials

Thus, analysing the root causes of waste plays an important role in the management of production systems, as it is an efficient way of assessing their performance and pointing out potential areas for improvements.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Chapter 2 is an overview of the generation of construction waste. This chapter is written based on previous researchers' works and interpretations. The significance of analysing the root causes of mishandling material is established. Identifying the critical root causes are always important to solve an issue.

2.2 Definition of construction

Construction projects comprise of project planning, management, and scheduling. Nevertheless, every construction project requires a variety of products that go through a manufacturing process to meet a specified quality output. The definition of construction is presented in Table 2.1.

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Table 2.1: Definition of construction

Num.	Concept of Construction	References
1	Building operations generally refer to several events, such as construction works, tunnelling, road works, bridges, and airfields.	Saadi *et al.*, (2016)
2	Installation, alteration, relocation, deployment, commissioning, reconstruction, restoration, improvement, painting or other repairs, decommissioning, removal or destruction of a building.	Williams *et al.*, (2016)
3	Construction is defined as the activity causing waste generated such as scrap, damaged or spoiled materials, temporary and expendable construction materials, and aids that are not included in the finished project, packaging materials, and waste generated by the workforce.	Napier (2016)
4	Four crucial elements play a significant role in construction (material, manpower, money, machine).	EPD (2015)

Thus, construction is defined as the process that includes design work, and installation includes complex communication and management work in coordination environments involving a large number of individuals.

2.3 Global construction waste in construction industry

There are many other countries also affected by the construction waste. The facts about the other country's construction waste generation shows that construction waste has been a pressing issue not only in Malaysia nor other developed and developing country as described below:

2.3.1 Singapore

According to National Environmental Agency (NEA), 825 000 tonnes of construction and demolition (C&D) waste were produced in Singapore on year 2020. Singapore aims for zero construction waste and had successfully achieve 100% recycling rate for construction and demolition waste. Usually, construction and demolition waste sorted for the recovery of materials such as metal, wood, plastic, paper and it processed into aggregates to reuse for upcoming construction activities. It is done by manually or by machines such as magnetic separators at recycling companies. This protocol has led to the invention of some new materials as recycled concrete aggregate (RCA), which is made up from 70% of demolition waste, reclaimed from waste concrete made with

natural aggregates. Besides, an eco-green building also constructed by using concrete with up to 100% recycled construction materials in Singapore.

2.3.2 Pakistan

In Pakistan, 30% of the total solid waste generated is estimated to be comprising of construction and demolition waste (Wakade *et al*., 2010). However, construction waste in Pakistan is not established properly and ultimately it becomes a segment of solid waste that dumps in landfills (Qamar & Khurram, 2017). According to International Trade Administration, Pakistan generates about 48.5 million tonnes of solid waste a year, which has been increasing more than 2 percent annually. Like other developing countries, Pakistan lacks waste management infrastructure, creating serious environmental problems. As that, Karachi which is Pakistan's largest city, generates more than 13,500 tonnes of municipal waste daily. Besides, in Pakistan, 30% of the total solid waste generated is estimated to be comprising of construction and demolition waste (Wakade & Sawant, 2010). Therefore, to address the issue of solid waste transfer and recycling of construction and demolition waste, Lahore Waste Management Company (LWMC) has planned to construct the first ever transfer station and recycling facility near Thokar Niaz Baig. However, construction waste in Pakistan is not established properly and ultimately it becomes a segment of solid waste that dumps in landfills (Qamar &Khurram, 2017; Yeheyis *et al*., 2013; Poon *et al*., 2001).

2.3.3 China

According to South China Morning Post, due to rapid urbanization China has produced more than 1.5 billion tons of waste yet only 100 million tons of waste has been properly disposed or recycle. Construction and demolition waste (CDW) in China reported 30% to 40% of the total amount of waste (Huang *et al*., 2018). The waste is usually disposed or dumped in landfills and the average rate of recycling CDW in China is about 5%. A report from National Development and Reform Commission of China stated that China produced five times more construction waste in 2013 than the measure of municipal waste created in China in a similar period. However, little of the construction waste was recycled or reused (Duan, 2016). In China it is considered as a

big challenge in adoption of circular economy in CDW industry while the related research is still limited. Especially, major scale urban development programs, such as wide urban restoration programs in metropolitan cities, have produced high construction waste and remarkable ecological effects (Li *et al.*, 2017).

2.3.4 India

India faces environmental challenges in terms of waste management associated with waste generation and inadequate waste collection, treatment, transportation and disposal (Kumar *et al*., 2017). According to the Building Material Promotion Council (BMPTC) on year 2020, India generates an estimated 150 million tonnes of construction and demolition (C&D) waste every year, yet the official recycling capacity is a meagre 6,500 tonnes per day and it is merely just 1%. According to Shrirastava & Chini (2009), estimatedly India generates24 million tonnes of C&D waste on year 2010. Jain *et al*., (2018) and Ram & Kalidindi (2017) pointed out that estimated quantum of C&D waste generation in India showed huge variations, and therefore it is potentially unreliable and inexplicitly documented. India government stated that 12–15 million tonnes of C&D waste were produced in India every year (TIFAC 2001; BMTPC 2016). According to a study done by independent organization Development Alternatives (DA) in India, annually 750 million tonnes of C&D waste is generated in urban areas of India (Development Alternatives 2015).

2.3.5 United States of America (USA)

According to United States Environmental Protection Agency (EPA), United States generated over 600 million tonnes of construction related waste in year 2018. Besides, 600 million tonnes of C&D debris was generated in year 2018, which is more than twice the amount of generated municipal solid waste. Moreover, EPA estimated that 136 million tonnes of building-related C&D materials were generated in the United States back in year 1996. But by 2003, almost 170 million tonnes of C&D wastes were increasingly generated. Some research works have discovered that the construction waste generation extends about 700 kg/m^2 (Abarca-Guerrero *et al.*, 2017). Relatively, all or part of the construction waste stream is unlawfully disposed on land, or in

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