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Cost Implication Analysis of Concrete and Masonry Waste in Construction Project

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ABSTRACT

Concrete and masonry waste are the main types of waste typically generated at a construction project. There is a lack of studies in the country regarding the cost implication of managing these types of construction waste To address this need in Malaysia, the study is carried out to measure the disposal cost of concrete and masonry waste. The study was carried out by a site visit method using an indirect measurement approach to quantify the quantity of waste generated at the project. Based on the recorded number of trips for waste collection, the total expenditure to dispose the waste were derived in three construction stages. Data was collected four times a week for the period July 2014 to July 2015. The total waste generated at the study site was 762.51 m^3 and the cost incurred for the 187 truck trips required to dispose the waste generated from the project site to the nearby landfill was RM22,440.00. The findings will be useful to both researchers and policy makers concerned with construction waste.

Keywords: Construction project, cost analysis, concrete and masonry waste, indirect measurement, sustainable

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INTRODUCTION

The construction sector plays a vital part in Malaysia's economic development. Rapid urban development, such as the construction of buildings and infrastructure projects have however led to the large construction waste generation and the increasing problem of illegal disposal (Begum et al., 2007). According to Mei and Fujiwara (2016), construction waste in Central and Southern Malaysia accounts for 28.34%. Furthermore, a study in Johor indicated 42% of 46 illegal dumping sites are construction waste material (Rahmat & Ibrahim, 2007). A study by Liu et al. (2012), highlighted the urgency of estimating construction waste using scientific and other rational methods or more efficient management of the government.

Concrete and masonry waste needs to be managed and handled carefully (Nagapan et al., 2013; Faridah et al., 2004). This study has been conducted to measure the quantity of concrete and masonry waste generated at the site to ascertain the cost related to its management.

Previous Research Works

There are many studies on waste generation rates. Table 1 delineates a summary of previous studies that investigated waste generation rates. In general, there are two approaches for measuring waste generation: by classifying waste into different categories or treating them as a whole. It can be seen from Table 1 that different practices were applied to measure waste either by weight (kg or ton) or by volume (m^3). Bossink and Brouwers (1996), investigated waste by differentiating materials such as steel, cement, concrete, mortar, timber, and packaging waste. A study by Formoso et al. (2014) has summarized there are four typical measurements of waste generation rate such as a percentage of material purchased, percentage of material required by the design, kg/m^2 of Gross Floor Area (GFA), and m^3/m^2 of GFA. Meanwhile, professional standard and the classification system for waste generation rate was used by Liu et al. (2012) in China. In this study, the estimation methods using Apparent Constructed Volume and Apparent Wreckage Waste Volume were used. It contrasts with other studies which have used direct measurement method of stockpiled waste volume (m^3) on site using rectangular or pyramid based assumptions studies by Lau et al. (2008) and Nagapan et al. (2013). Poon et al. (2004) conducted research through direct observation, tape measurement, and truck load records. It can be seen that research of this kind normally adopts hard methods of measuring waste, such as on-site sorting and weighing and truck load records. This method requires precise information and easy access to accurate data on the amount of waste that are disposed from the site using trucks. The aim of this study is to quantify the cost implication analysis for the concrete and masonry waste. Indirect measurement by weighing truck load records has been adopted for this study.

Table 1
Summary of waste generation rate study from past researchers.

Author	Country	Measurement of Generated Construction Waste	Methodology	Conclusions
Bossink and Brouwers (1996)	Netherland	Percentage by weight (purchased material)	Sorted and weighed the waste materials	1-10% weight of the amount purchased for seven materials, with an average 9% end up as waste.
Formoso et al. (2002)	Brazil	Waste (%) = $[(M_{purchased}\text{-}Inv)\text{-}\ M_{designed}]/M_{designed}$ where Inv indicates the final inventory of materials	Direct observation and contractors' records	19.1–91.2% by weight according to the amount purchased for eight materials
Poon et al. (2004)	Hong Kong	The volume (m3) of waste generated per m2 of gross floor area	Visual inspection, tape measurement, truck load records	The total waste generation rate:0.176m3/m2 (Construction) and 0.4–0.65m3/m2 (Demolition)
Lau et al. (2008)	Malaysia	Measure the stockpiled waste volume(m3) on site using rectangular or pyramid based assumptions	Direct measurement using measuring tape and interviews	Wood is highest construction waste material in Site A and B, Concrete is highest waste generator in Site C.
Liu et al. (2012)	China	The classification of waste item has referenced a relevant professional standard and the classification system is hierarchic, in which the list of construction wastes is divided into different levels, such as chapters and sub- chapters	Estimation Method using Apparent Constructed Volume and Apparent Wreckage Waste Volume	Waste generation of 0.34 m3/m2 (Soil is considered) for the new construction projects and generate the biggest volume are soil, concrete and bricks.
Nagapan et al. (2013)	Malaysia	Method adopted from Lau (2008), measure the stockpiled waste using pyramid or rectangular based assumptions.	Direct measurement using measurement tapes	Six types of construction wastes found at the sites were timber, metal, bricks, concrete, packaging waste and mortar. Timber waste was the dominant waste at all of the sites.

MATERIALS AND METHODS

Demography of the Project Site A

To maintain its anonymity, this project is labelled as Site A, which is located in Johor, Malaysia. It is a mixed development with shop office, boutique outlet and service residences. The project started in May 2014 and was estimated to be completed in August 2016, and worth more than RM250 million.

Concrete and Masonry Waste

Concrete and bricks are important construction materials used in construction. (Shen et al., 2010). Mana Reixach et al. (2000), stated that masonry works mixture of concrete, bricks, tiles and ceramic materials generated high construction and demolition waste in Spain. The waste consists of bricks, stone, concrete block, plaster debris and block tile (Ong, 2009). Figure 1 shows Concrete and Masonry Waste that were collected and mixed up at Project Site A. In this project, waste collectors provide special waste bin for concrete and masonry waste due to the heavy waste load.

Figure 1. Concrete and masonry waste

Quantifying and Costing Methods

The study used a site visit method and an indirect measurement approach that weighed truck load records adopted from Poon et al. (2004). The number of trucks for waste collection is recorded 4 times weekly over a 12-month period. . The truck's bin size is Length (L) = 3.6576 m (12'), Width (W) = 1.8288 m (6') and Height (H) = 0.6096 m (2') as shown in Figure 2.

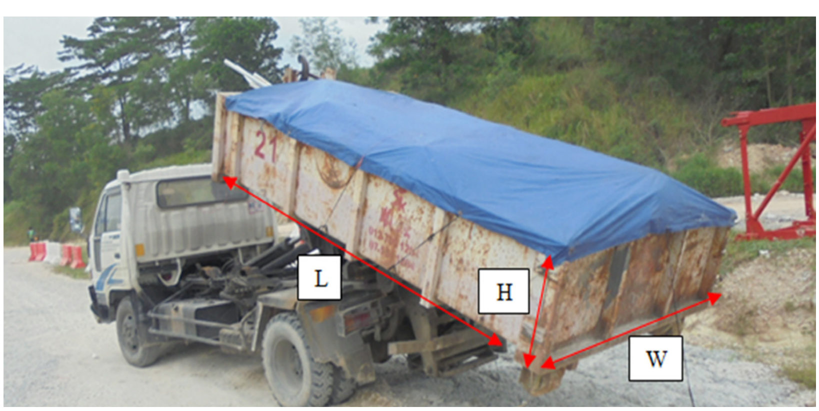

Figure 2. Measurement (L x B x H)

The volume of the bin is calculated in cubic meter (m^3) to quantify the waste which had been disposed. Meanwhile, the amount of cost for managing concrete and masonry waste is rated per trip. Based on the project's contract agreement, each trip is charged RM120.00 by the roll off the truck to transport out the concrete and masonry waste. The amount for transporting the waste out is calculated by the Total Number of Truck Trips times the Charge per Truck Trip (Total Truck Trips × RM120.00).

RESULTS AND DISCUSSION

Table 2 presents the total volume of concrete and masonry waste generated for 12-month period and total cost that had been expensed to remove this waste from project site to the landfill.

Table 2
Summary of waste generated in cubic meter and total amount expenditures for waste collection

No	Construction Stages	Size of Bin Month	(12' x 6' x 2') Trip Per Month	Volume (cubic meter)	Rate (RM)	Amount (RM)
1	Pre-Construction	Jul-14	1	4.08		
2	Stages and Phase 1&	Aug-14	2	8.16		
3	2 RC Works	Sep-14	2	8.16	120.00	240.00
4		Oct-14	7	28.54	120.00	840.00
5	Podium Carpark	Nov-14	8	32.62	120.00	960.00
6	RC Works and	Dec-14	13	53.01	120.00	1,560.00
7	Architecture Works	Jan-15	18	73.40	120.00	2,160.00
8	For Phase 1	Feb-15	10	40.78	120.00	1,200.00
9	Phase 2 Service	Mar-15	33	134.56	120.00	3,960.00
10	Residence RC	Apr-15	40	163.10	120.00	4,800.00
11	Works and	May-15	27	110.10	120.00	3,240.00
12	Architecture Works	Jun-15	26	106.02	120.00	3,120.00
		Total	**187**	**762.51479**		**22,440.00**

Pre-Construction Stages and Phase 1 & 2 RC Works

In the preliminary stages of construction site clearing, site office set up, site mobilization and basement reinforced concrete works began. The site was handed over to the contractor on June 2014. It can be seen from Table 2 that the number of concrete and masonry waste slowly increased at this stage. By October 2014, the number of waste generated was high (28.54 m^3) as sub-contractors started to complete the Basement and Phase 1 (Shop Office and Boutique Outlets) RC Works.

Podium Carpark RC Works and Architecture Works for Phase 1

This is the intermediate stage where RC works began for Phase 2 Podium Carpark. The area of the Podium Car Park is approximately 4300 m^2 with 5 levels. Architectural works commenced for Phase 1 with brick wall and plastering works. The concrete and masonry waste generated was significantly higher at this stage due to slab and beam structure works, ramp construction, lift shaft works, brickworks, ceiling plastering, skim coat plastering and external plastering works.

Phase 2 Service Residence RC Works and Architecture Works

Based on the site visit method, this is the crucial stage in the project site. At this stage, the structural works for service residences commenced utilising the IBS system formwork as the main construction method. This project achieved project cycle of 5 floors per month, hence generating high concrete waste. Besides that, masonry waste generation was also high due to the fact that the contractor had to catch up with the progress of architectural works for Phase 1 completion works. The results showed the highest concrete and masonry waste produced was 163.10 m^3 and the amount spent on waste collection for the month was RM4,800.00.

CONCLUSION

Through this study, a database for concrete and masonry waste at Project Site A is determined. There are two major findings from this study, which include: (i) concrete and masonry waste generated for the 12 month period at Project Site A is 762 m^3; and (ii) the total expenses to dispose this waste is RM22,440.00 based on 187 trips, or RM29.45 per m^3. Thus indicating proper concrete and masonry waste management practices at the site can be cost saving, beneficial and sustainable.

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