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A survey of Construction and Demolition Waste in Malaysia, Mixed-Use Development

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Malaysia is witnessing a rapid development of its urban centers, and where construction and demolition (C&D) waste generation is increasing proportionally with the new construction industry development. Under current construction methods, with minimal recycling, with most C&D waste is dumped to the landfill. This study seeks to investigate the current waste generation rate in mixed-development projects within Malaysia, and the role of different construction methods in total waste generation. This study works around existing data limitations to develop a logical modeling that is predictive, practical and applicable to the construction industry in Malaysia. This study samples a total of eleven (11) construction sites. Of those sites sampled, six (6) projects use conventional construction method, four (4) projects use the mixture of system formwork and conventional construction method, and one (1) is the site of a demolition project. The theoretical framework developed in this study demonstrates the waste generation rate and the efficiency of construction method in influencing WGR. Waste generation rates estimated from this study serve as a measurable indicator to creating understanding of resource allocation and to provide the necessary foundation for future project planning, efficient material flow, site planning, and waste management planning, for development in an economically and environmentally sound manner.

Key words: *construction waste, demolition waste, quantification, waste composition, waste estimation*

1 INTRODUCTION

The construction industry has accounted for approximately 41% of the total solid waste generation in Malaysia (MHLG, 2012). Construction waste generated in Central and Southern Malaysia, alone, accounts for 28.34%. According to Fauziah and Agamuthu (2003), construction and demolition ("C&D") waste generation was estimated at 161.19 tons per day in 2009, increasing to 299.69 tons per day in 2015, and is projected to reach 368.31 tons per day by 2023 (Fauziah & Agamuthu, 2003).

Current C&D waste management practice, set by market incentives and business practicalities, results in en masse landfill dumping practices. The minimal level of recycling is attributed to a dearth of appropriate recycling and secondary market infrastructure. In (Begum, Siwar, Pereira, & Jaafar, 2009) research study, it was revealed that 70% of contractors did not practice waste separation unless mandated by specific private contract provisions.

Over the past decade, rapid urbanization and insufficient attention to C&D waste generation, particularly in developing countries like Malaysia, have contributed to an urgent need for additional research on waste generation (Begum, Siwar, Pereira, & Jaafar, 2007; Wang, Yuan, Kang, & Lu, 2010).

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2 METHODOLOGIES

There are several methods for estimating or quantifying C&D waste. Waste can be estimated either by waste generation quantity or by waste disposal quantity (Franklin Associates, 1998). Waste quantity or volume can be obtained by waste truck trip and size of the waste bin (Poon, Yu, & Jaillon, 2004). However, the quantification method must be modified to comport with the limitations of data quality and availability (Mahayuddin & Zaharuddin, 2013). A universal waste quantification model can rarely be applied, as the nature of C&D waste data is dependent upon the local economic condition, weather, disaster, local regulation, availability of technology, labor and resources (Franklin Associates, 1998).

Step 1) Calculate the waste disposed out of site by counting the total number of waste disposal container use for C&D waste disposal throughout the project construction. Disposal container is obtained from site measurement and review of contractor claim reports.

$$V_{all} = V \times N \tag{1}$$

Step 2) Calculate the number of disposal containers utilized by review of contractor claim reports, delivery orders, and invoices.

$$N = C_{all}/C \quad (2)$$

Step 3) Estimate the waste composition through structured interview and site observation.

$$VCom(k) = Vall\,.\,Com(k) \quad (3)$$

Step 4) Calculate waste generation rate (WGR). In this study, WGR of waste category k is defined as following equations:

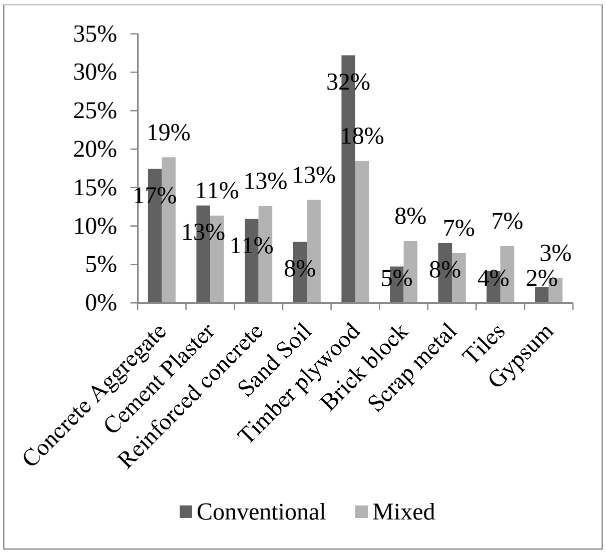

Fig. 1 Waste composition of conventional and mixed development

Table 1 Waste generation rate

Construction Method	Project	Volume Waste (m³)	Floor area (m²)	WGR (t/100m²)
Conventional	1	2148	17300	13.79
	2	12969	96405	13.86
	3	18396	182827	11.33
	4	5500	61006	8.86
	5	9764	91029	12.54
	6	7776	86897	10.39
	Average	-	89244	**11.79**
Mixed	7	4792	217279	2.47
	8	2097	68670	3.57
	9	4296	119259	4.56
	10	2610	45583	7.25
	Average	-	112698	**4.46**
Demolition	11	135790	128985	130.86
	Average	-	128985	**130.86**

Results show that the different construction methods generate waste at different rates. The higher the WGR, the greater the waste generated. In average, WGR for conventional construction method is estimated at 11.79 tons per 100 square meters, while WGR mixed construction method is estimated at 4.46 ton per 100 square meters. This study finds that the conventional-construction method generates higher waste compared to mixed-construction, and appears to be more efficient.

3 CONCLUSION

$$WGR(k) = \frac{V_{all} \times Com(k) \times \rho(k)}{F} \quad (4)$$

Where F is project floor area (m²), N is number of disposal container (-), V is waste volume of one disposal container (m³), V_{all} is total volume of waste disposed (m³), C is cost per disposal container (RM), C_{all} is total waste disposal cost (RM), k *is* waste category (-), $\rho(k)$ is waste material density of waste k (t/m³), *Com(k)* is volume percent of waste composition of waste *k* (%), *VCom(k)* is volume of waste composition of waste *k* (m³).

The waste generation rate ("WGR") of development under the conventional-construction method is quantified at 11.79 tons per 100 square meters, substantially more wasteful than the mixed-construction method, which is measured to produce 4.46 tons of waste per 100 square meters of construction. Demolition project development waste is quantified at 130.86 tons per 100 square meters, though bearing a very different waste composition and recyclability profile. The theoretical framework developed in this study demonstrates the waste generation rate and the efficiency of construction method in influencing WGR. Waste generation rates estimated from this study serve as a measurable indicator to creating understanding of resource allocation and to provide the necessary foundation for future project planning, efficient material flow, site planning, and waste management planning, for development in an economically and environmentally sound manner.

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