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GENERATION AND MANAGEMENT OF WASTE IN RESIDENTIAL CONSTRUCTION

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ABSTRACT

Construction waste profile is important to assess the viability of good waste management practices. However, little information is known about the quantity and characteristics of construction waste generated and its management. Lack of understanding, results in improper waste management practice. The generation and characterisation of construction waste have to be identified together with current waste management practice. Therefore, a series of site audit has been carried out in several on-going housing projects in Ipoh, Perak, Malaysia. The calculation of the total construction waste quantity and the floor area constructed gives a generation rate of 16.55 kg/m^2. This rate should be disseminated to all parties involved in construction with a view towards widespread use in future construction waste estimation. It will be an incentive to the development of an integrated waste management system and the implementation of good practices for managing construction waste. Recommendations are made in order to improve construction waste management in Ipoh.

Keywords: construction waste, waste management, housing, Ipoh

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INTRODUCTION

An increase in construction activities brings negative impacts to the environment through the generation of waste, ecological imbalance, changes in living environment through the generation of waste, sewage, reduction in environmental resources and energy usage (Yip 2000). Solid and chemical wastes are found to be the most common contamination source from construction sites (Pun et al. 2001). Construction waste is generated during the construction process such as during site clearance, material use, material damage, material non-use, excess procurement and human error (Macozoma 2002). The composition and quantity of construction waste generated depends on the construction methods and materials used during construction activities (Formoso et al. 2002). The generation of construction waste is predictable, based on the building design and procurement of the building materials; thus it can be expected and hence controlled. However, the avoidance of waste generation in construction site is unpredictable due to lack of readily available data on construction waste from previous projects (Garas et al 2001). Furthermore, construction companies could not provide relevant and appropriate data because they are not obliged to record and report the quantitative characteristics of waste generated at their sites (Fatta et al. 2003). In addition, ineffective waste management practiced at construction site increases the generation of construction waste. A critical step to develop comprehensive waste management system is by categorization and quantification of construction waste (Gavilan & Bernold 1994). The quantification of construction waste needs to be done early in the construction project. However, it is difficult to determine the exact quantity generated as well as the exact composition of construction waste at construction sites. The occurrences of fly tipping or illegal dumping also give challenges to the estimation of construction waste quantity (Kofoworola & Gheewala 2009). The natural characteristic of construction waste which is highly variable in its compositions also brings difficulty in waste quantity estimation (Gavilan & Bernold 1994). Without the ability to specifically identify the characteristics of construction wastes being generated on construction sites, the site management would be unable to accurately track, monitor and quantify the total amount of wastes generated. Hence, accurate waste measurement would provide an effective method to evaluate the production system performance as it shows the improvement potential and identification of the major inefficient factors (Formoso et al. 2002). Construction waste quantity acts as an indicator to benchmark the construction

waste management practices whether standard, good or best practices.

The construction waste can be estimated by the building area, building demolition works and converting the construction and demolition waste quantitative data (Fatta el a. 2003). Another method of estimation is through the use of a construction waste index (Poon et al. 2001a). In Malaysia, the construction waste quantity is required for the planning and provision of capacity, location and total facilities and equipment to achieve Solid Waste National Strategic Plan target (MHLG 2005). Then, a monitoring system and continuous performance assessment could be implemented. However, very little information is known about the volume and characteristics of construction waste generated and its management at local level. Therefore, a study was conducted in one of the cities in Malaysia to access the current status of construction waste management. This study was based in Ipoh, the capital city of the state of Perak in northern Malaysia. Ipoh covers an area of 387.63 square kilometres with a population of 562,500 in 2005 (Town and Regional Planning Department (JPBD) Perak 1998). In comparison to the other areas in Perak, construction activities in Ipoh are higher due to its function as the main administrative centre where major industrial, commercial and residential areas are concentrated. The study focused on estimating waste generation at housing construction sites and identifying the current practices of waste management by the local contractors. Thus with better understanding of construction waste profile at local level will enhance the promotion of good practices of construction waste management.

RESEARCH METHODOLOGY

To meet the research objectives, a series of site audit has been conducted at nine fairly similar private housing construction sites in Ipoh. All these sites were at superstructure stage, comprised terraced houses, constructed with conventional reinforced concrete and brick wall. These requirements were set to standardise the observation criteria and collection of data at the construction sites and also to enable uniform comparison to be made among the sites. The distribution of data is not influenced by the geographical situation but depends on the types of house, specific practice by the contractors and lack of uniform standard in disposal and storage of the waste sample (Franklin Associates 1998).

An audit form was used during the site audit which was developed based on a review of literature, results of an earlier visit to several housing construction sites and interviews with site managers and site supervisors in Ipoh to identify current waste management practices at construction sites. The form has four major sections, namely general information on respondents, housing project profile, construction waste data and construction waste control.

The quantities of waste were estimated by the transportation records of waste disposed off from the construction sites (Poon et al. 2004). The estimation of waste quantity was calculated based on the waste transportation trip record, truck load and frequency of waste disposal activities. All the data gathered from the site audit were computed in MS Excel for the calculation of estimated quantity of construction waste generated at every site. Therefore, the waste was estimated by using Equation 1 adopted from Poon et al. (2004). However, this study estimates the waste quantity according to weight which is different from an earlier study by Poon et al. (2004). This is consistent with the landfill charges imposed in Malaysia and the unit used in the National Strategic Plan for Solid Waste Management (MHLG 2005).

$$W = V \times N \qquad \text{Equation 1}$$

where:

- V = truck load (tonne)
- N = total no of trucks for waste disposal
- W = total waste generated from the project (tonne)

The construction waste index was then calculated by using Equation 2, adopted from Poon et al. (2004).

$$C = \frac{W}{GFA} \qquad \text{Equation 2}$$

where:

- V = truck load (tonne)
- N = total no of truck for waste disposal
- W = total waste generated from the project (tonne) = $V \times N$
- GFA = gross floor area
- C = waste index (i.e construction of 1 m^2 gross floor area generates C tonne of waste)

Data on the ccurrent practices of waste management at housing sites in Ipoh were analyzed using the Statistical Package for Social Sciences (SPSS) and Microsoft Excel. Simple descriptive analysis such as frequency and mean had been calculated for all the variables. Meanwhile, relative importance index had been calculated to identify the ranking of statements regarding current practices of construction waste management at the audited sites. To determine the relative ranking of factors, the scores were transformed to important indices based

on Equation 3 (Kometa et al. 1994; Tam et al. 2000; Tam 2008).

$$RII = \frac{\sum w}{AN} \quad \text{Equation 3}$$

where w is the weighting given to each factor by the respondent, ranging from 1 to 5 in which '1' is the least important and '5' the most important; A is the highest weight which is '5' in this study; N is the total number of samples and RII is the relative important index, $0 \leq RII \leq 1$. The higher the index value means the higher is the ranking.

RESULTS AND DISCUSSION

Construction site profile

Table 1 presents the profile of the housing construction sites involved in this site audit. Most of the housing projects' duration is 24 months, with an average work progress of 59.4% completed. The number of constructed houses at the nine sites varies from 18 units to 235 units with an average total gross floor area for one site is 9650.7 m^2.

Waste generation at housing construction sites

During the site audit, only seven sites were able to provide information on waste transportation trip for the estimation of waste quantity as shown in Table 2. These estimations were used to calculate the construction waste index in this study. Five of the seven sites had disposed off their construction waste regularly. Meanwhile the other two sites,

TB1 and TB3 provided their estimation for the composition and quantity of waste expected to be disposed off from their projects. TB8 and TB9 were excluded from the estimation as they were unable to estimate the quantity of waste generated from their sites. In addition, TB9 divulged that all the construction waste generated at their site will be disposed off at the allocated areas on the site itself

Table 2: Estimated waste quantity at the project sites in Ipoh

	TB 1	TB 2	TB 3	TB 4	TB 5	TB 6	TB 7
Total waste transportation trip	0	4	0	10	10	6	30
Truck load (tonne)	10	3	1	10	10	10	10
Waste estimated quantity (tonne)	10*	12	1*	100	100	60	300

* Early estimation due to lack of construction waste disposal activities during site audit exercise

Table 1: Housing construction site profile in Ipoh

Site	Location	Project duration (month)	Work progress	Project cost value	Total constructed house (unit)	Total gross floor area (m^2)
TB1	Jalan Gopeng	24	80%	> MYR10 million	108	16524
TB2	Pasir Puteh	-	75%	MYR5-10 million	100	16560
TB3	Jalan Gopeng	24	60%	MYR5-10 million	50	6750
TB4	Gunung Rapat	24	70%	MYR5-10 million	84	11854.08
TB5	Seri Rapat	18	30%	MYR1-3 million	58	7308
TB6	Jelapang	24	55%	MYR500,000-MYR1 million	18	2494.8
TB7	Chemor	-	85%	MYR1-3 million	33	4395.6
TB8	Lahat	30	40%	MYR1-3 million	235	17730
TB9	Klebang	132*	40%*	> MYR10 million *	24	3240

* This information refers to the whole housing project for TB9. The total gross area reflects 24 units of terraced house under construction only.

Figure 1 shows the different level of work progress among the construction sites and the estimated quantity of waste generated at the sites. The TB7 site with a construction work progress of 85% had disposed 300 tonnes of waste. But TB1 site with similar work progress estimates to dispose 10 tonnes of waste. Therefore, the average quantity of waste generated from the two sites is 83.3 tonnes with an average work progress of 65%. The variability in the quantity of construction waste generated depends on the efficiency of site

management and work practices during construction activities.

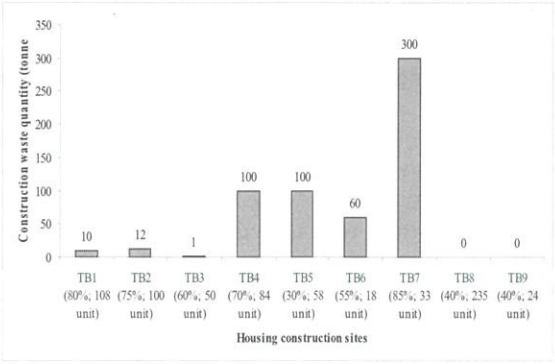

Figure 1: Estimated waste quantity according to construction work progress, among the audited sites.

Figure 2 shows the types and composition of construction waste at the selected project sites in Ipoh. The major composition of construction waste generated at the studied site are soil, aggregates and sand; with an average of 44.3%. This is followed by wood (12%) and insulation material for ceiling (9.3%).

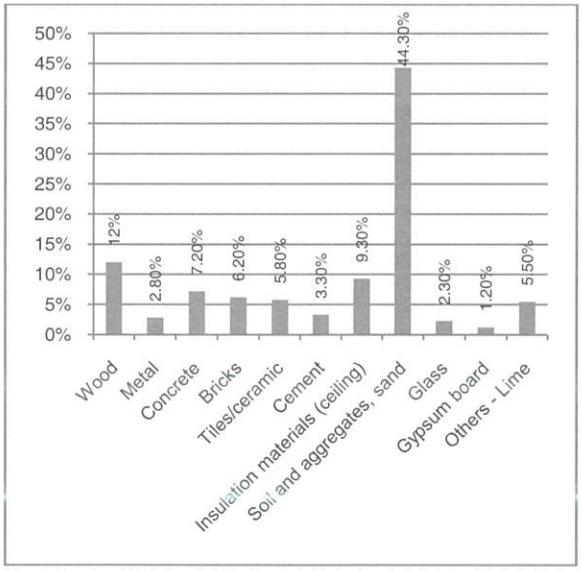

Figure 2: Average composition of construction waste at the selected project sites in Ipoh

The estimation of waste quantity from Table 2 and the total gross floor area (Table 1) produce the generation rate for construction waste as shown in Table 3. The average construction waste generation rate for the seven housing sites is 16.55 kg/m^2. Therefore, the estimated quantity of waste from one unit of house with an average floor area of 146.1 m^2 will be 2418 kg.

Table 3: Construction waste generation rate at housing projects in Ipoh

Site	Total gross floor area (m^2) (A)	Estimated waste quantity (tonne) (B)	Construction waste generation rate (tonne/m^2) (C=B/A)	Construction waste generation rate (kg/m^2)	Average construction waste generation rate (kg/m^2)
TB 1	16524	10	0.000605	0.60	16.55
TB 2	16560	12	0.0007246	0.72	
TB 3	6750	1	0.00015	0.15	
TB 4	11854.1	100	0.0084359	8.44	
TB 5	7308	100	0.0136836	13.68	
TB 6	2494.8	60	0.02405	24.05	
TB 7	4395.6	300	0.0682501	68.25	

The generation rate found from this study is almost similar to the findings by NAHB (1995). They had performed an evaluation and estimation on three housing construction sites in the United States of America. The waste generation rate from the study was 21.5 kg/m^2 and the total estimated quantity for a typical residential unit with an area of 186 square metres was 4000 kg. Meanwhile, the waste generation rate for different types of buildings in the United States of America was found to be between 20 to 30 kg/m^2 (Peng et al. 1997). It is difficult to directly compare the waste generation rate between countries because of the various techniques, work procedures and construction practices employed (Yahya and Boussabaine 2006). For example, the generation of construction waste in Kuwait is higher than the total international quantity due to the Gulf War and the lack of material management in the construction industry (Kartam et al. 2004). The composition and quantity of construction waste generated on sites depend on the construction methods and materials used during construction activities (Formoso et al. 2002). The difference in waste composition is also caused by the different construction methods and technology used, workers' skill and building designs (Poon et al. 2001b). Hence, experience, information and technologies related to the management of construction waste from various countries can be shared in order to overcome the problems caused by the generation of construction waste.

The construction waste generation rate found from this study is beneficial to local contractors and housing developers in Ipoh to estimate the generation of waste for their future housing projects. The index also indicates the benchmark of the waste management practices at housing sites. Thus, the construction sector and local authorities can plan for an effective waste management strategy early. However, the index from this study is not conclusive due to small number of

audited sites. The index will be subjected to change once additional waste data are available from other projects. Therefore more sites are needed for the waste audit to develop a construction waste index that is more representative of the local construction industry.

Current practices of waste management at housing construction sites

The site audit has identified the current practices of waste management at housing construction sites in Ipoh. The practices include the waste management sources and facilities, waste management hierarchy and disposal of waste from the construction sites.

Sources and waste management facilities in housing construction sites in Ipoh

The waste management sources and facilities at the audited sites include an action plan, specific workers and waste record as shown in Table 4. Meanwhile the waste management facilities consist of equipment and location for collection and sorting of waste, condition of waste collected and re-use, and recycling facilities. It is found that 67% of the sites audited provide a waste reduction action plan and appoint a specific worker to manage waste. There is also lack of waste record as only 22% of the construction sites record the generation of waste at their sites. Most of the sites record the waste transportation trip by keeping the transportation charges receipts. Other sites keep the tipping receipts from the MBI landfill as their record. This shows that no formal recording activities applied for the management of waste.

The site audits found that 67% of the sites allocate a specific area for waste collection. But TB6 and TB9 also used that area for construction waste disposal. Mostly the allocated area is still undeveloped. Sometimes the allocated area is used for temporary collection before the final disposal to the Bercham landfill. Normally the disposal actvities at the sites are managed by the housing developer with their own transportation vehicle. During the site audit, construction waste can be found everywhere near the working area. It is found that 56% of the sites temporarily pile the construction waste in a scattered manner. Meanwhile 22% of the audited sites provide bins for waste collection. And 33% of the audited site provide a specific area for waste sorting activities. The other 22% of the audited sites provide bins for waste recycling and re-use. Piles of unsorted waste at the audited sites lead to a mix of different types of construction waste. Thus, this makes reuse and recycling of construction waste difficult.

The large number of sub-contractors involved in construction works at one site makes waste management activities complicated. For example, there are 11 sub-contractors involved in one of the audited site for various trades such as aluminium works, ceiling works, tiling works and painting works. This makes the identification of the responsible party for the waste generated from each work trade difficult. Morever, the main contractor and the housing developer are unable to identify the actual waste management practices by the sub-contractor. However every sub-contractor is responsible to manage the construction waste generated from his own work trade. Sub-contractors play an important role to reduce the generation of waste on construction sites (Gavillan & Bernold 1994). For example, two different contractors who do a same trade may produce different quantity of construction waste due to various factors such as work skill, attitude and construction method used.

Table 4: Sources and waste management facilities in housing construction sites in Ipoh

Sources and facilities in construction sites	No of construction sites		Percentage of construction sites	
	Yes	No	Yes	No
Company has an action plan to reduce waste	6	3	67%	33%
The construction site appoints special/specific workers to manage waste	6	3	67%	33%
The construction site records the quantity of waste generated	2	7	22%	78%
Provision of special bins for waste collection before final disposal	2	7	22%	78%
Provision of specific area for construction waste collection	6	3	67%	33%
Construction waste is collected randomly at the construction sites (no specific area provided)	5	4	56%	44%
Provision of specific area for waste sorting	3	6	33%	67%
All types of construction waste are mixed and collected together	6	3	67%	33%
The construction site provides bins for re-use and recycling of material waste	2	7	22%	78%

Waste management hierarchy at housing sites

Table 5 shows the waste management hierarchy at the audited sites. The highest rank is reuse on site with RII of 0.582, followed by recycle on site at 0.473 RII. Then disposal of construction waste becomes the third rank, and leave-on site is the fourth rank. This finding indicates low level waste management practices at construction sites in Ipoh according to the waste management hierarchy outlined in the Solid Waste National Strategic Plan.

Table 5: Waste management hierarchy at housing construction sites in Ipoh

	$\sum w$	RII	Ranking
Reuse on site	32	0.582	1
Recycle on site	26	0.473	2
Dispose	19	0.345	3
Leave-on site	16	0.291	4
Reuse off site	15	0.273	5
Sell to third party (sell to others)	15	0.273	5
Recycle off site	14	0.254	7
Others	11	0.200	8
Give to others	10	0.182	9

The disposal activities for the site audit have been divided into dispose offsite and leave-on sites. Dispose offsite means that all the construction waste will be transported out from the site for final disposal. A majority of the disposed waste found in the site audit consist of excavated soil from land levelling, sewerage, drain, underground pipe and piling works. Meanwhile, leaving waste on sites involved burying waste or pile the waste scattered around the sites. This site audit estimates 1-30% of waste generated will be left on sites after the completion of construction works. For example, wood will be left to rot at TB6 site. Wastes were buried at TB7 and CCC3 sites. Rocks and aggregates were dumped into the excavated hole at isolated areas of the construction sites. This practice is preferable due to minimal cost involved and it is difficult to be noticed.

The fifth waste management activity is re-use of waste off sites. The housing developer brings the surplus building material from the completed housing project to other projects which are still under construction. The sixth and seventh ranks of the waste management activities are selling the waste to the other parties and recycling of waste. Steel is found to be the most collected waste and are sold to other parties. It is estimated that 1-30% of waste generated will be recycled offsite. One of the contractors at the audited sites admitted that recycling is costly since it involved cleaning of concrete, mortar and nail from the wood waste. The third party only accepts cleaned wood waste to be used as burning material in ceramic manufacturing. Therefore, the wood waste surface gives constraint to the selling and recycling of wood waste offsite.

The findings reveal that another least method practiced on site is to burn the damaged wood for about 1-30% of the wood waste generated. Burning of wood is found to be the easiest and cheapest way by the site management of TB6 and TB5. They admitted that they burn the wood waste in small quantity by stages to avoid being spotted by the Department of Environment. Packaging material was also openly burnt at the construction site. Meanwhile, the least waste management practiced on-site is giving away the construction waste especially the building material surplus to others. This practice is unpopular among the contractors because it is not profitable.

Disposal of construction waste from the housing sites

The site audit found that the construction waste transportation trip record was poor among the construction sites audited. Only 3 sites (37.5 %) of the sites kept transportation record of the waste transported out from their sites. A majority of the construction sites (62.5 %) do not have a fixed schedule and will transport the construction waste after completion of the project. The other two sites transport the waste every month. Only one site will transport the waste after completion of work by trade. Most construction sites (87.5%) rent a lorry for waste disposal transportation. The average lorry rental charge per day is MYR 335.

The physical condition of construction waste before being transported out from the housing construction site in Ipoh is shown in Table 6. It is found that 50% is mixed waste from various construction activities. Meanwhile 25% of waste collected is mixed but according to the types of construction activities. And 25% of the audited sites sort the construction waste according to the types of building materials.

Table 6: Construction waste physical condition collected before being transported out from the housing construction site in Ipoh

Waste condition	No of sites	Percentage (%)
All construction waste is mixed (various material and construction activities)	4	50
All construction waste is mixed (according to types of construction activities)	2	25
Construction waste is sorted according to the types of building materials	2	25

The waste transported out from the housing sites in Ipoh has been sent to several destinations as shown in Table 7. Waste disposal at the allocated dumpsite which is Bercham Landfill is ranked first with RII of 0.473. This is followed by re-use of building waste. Meanwhile, the other method such as burning is found to be the ranked last.

Table 7: Construction waste destination after being transported out from the housing construction sites in Ipoh

	$\sum w$	RII	Ranking
Dispose at the allocated dumpsite	26	0.473	1
Reuse	22	0.400	2
Dispose to other areas (outside the allocated dumpsite)	18	0.327	3
Recycle	18	0.327	3
Sell	14	0.254	5
Other methods – Burning (wood/bags)	9	0.164	6

Recommendations For Improvement Of Current Waste Management Practices At Housing Construction Sites In Ipoh

This study has identified the current status of construction waste management at several housing construction sites in Ipoh focussing on waste generation, waste management sources and facilities, waste management hierarchy and waste disposal practices. The findings show that local contractors need to improve their current construction waste management practices. In order to achieve that, three recommendations are made.

The first recommendation is to increase the level of education and knowledge of good waste management practices of the construction workers. This could enhance awareness among the workers on the importance of good waste management practices. Provision of regular talks on good practices of construction waste management would stimulate the workers' awareness.

The second recommendation is to increase the construction waste management facilities. Information on the generation and characterization of construction waste found in this study could be used to plan the provision of the facilities such as transportation and collection network, allocation of specific area for waste disposal to prevent illegal dumping or public filling at the ex-mining pond and set up of reuse and recycling centre. Thus, construction industry will have proper channel and support for better management of construction waste.

To improve the current practices, a suitable and local construction waste management plan is needed. So the last recommendation is to provide a waste management plan for the local construction companies. The proposed plan consists of five elements namely company administration, guidelines for management plan, prevention and reduction, optimisation of waste disposal and evaluation of good practices. So this plan acts as guidelines for good waste management at sites. To succeed, it should be precise, simple and practical to be implemented on site. Later, the plan could be used by the local authorities to monitor and control the generation and management of construction waste.

CONCLUSION

This study has identified the current status of construction waste management at several housing construction sites in Ipoh, in terms of the waste management sources and facilities, waste management hierarchy and waste disposal practices. The present scenario shows that waste management practice in Ipoh is below the good practices standard. However, the results obtained shall help improve current waste management practices in Ipoh by providing useful information regarding construction waste characteristics and the potential of construction waste generation rate as a reference for future projects to promote waste minimisation. In conclusion, better understanding of construction waste characteristics helps in proper planning and implementation of good waste management practices.

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REFERENCES

Fatta, D., Papadopoulos, A., Avramikos, E., Sgourou, E., Moustakas, K., Kourmoussis, F., Mentzis, A. & Loizidou, M. (2003). Generation and management of construction and demolition waste in Greece--an existing challenge. *Resources, Conservation and Recycling* 40(1): 81-91.

Formoso, C.T., Soibelman, L., De Cesare, C. & Isatto, E.L. (2002). Material waste in building industry: main causes and prevention. *Journal of Construction Engineering & Management* 128(4): 316.

Franklin Associates. (1998). Characterization of Building Related Construction and Demolition Debris in the United States. US EPA. EPA530-R-98-010.

Garas, G.L., Anis, A.R. & El-Gammal, A. (2001). Material waste in the Egyptian construction industry. Chua, D. B., Glenn. *Proceedings of the 9th International Group for Lean Construction Conference*.Kent Ridge Crescent, Singapore

Gavilan, R.M. & Bernold, L.E. (1994). Source evaluation of solid waste in building construction. *Journal of Construction Engineering and Management* 120(3): 536-552.

JPBD. (1998). *Draf Rancangan Struktur Ipoh (Penggubahan) 1998-2020.*

Kartam, N., Al-Mutairi, N., Al-Ghusain, I. & Al-Humoud, J. (2004). Environmental management of construction and demolition waste in Kuwait. *Waste Management* 24(10): 1049-1059.

Kofoworola, O.F. & Gheewala, S.H. (2009). Estimation of construction waste generation and management in Thailand. *Waste Management* 29(2): 731-738.

Kometa, S.T., Olomolaiye, P.O. & Harris, F.C. (1994). Attributes of UK construction clients influencing project consultants' performance. *Construction Management & Economics* 12(5): 433.

Macozoma, D.S. (2002). International report - construction site waste management and minimisation. International Council for Research and Innovation in Building and Construction (CIB). Report No. BOU/C361.

Ministry of Housing and Local Government (MHLG). (2005). National Strategic Plan for Solid Waste Management. Volume 2 Main Report.

NAHB. (1995). Residential Construction Waste: From Disposal to Management. NAHB Research.Centre. www.toolbase.org/tertiaryT.asp [16 April 2006]

Peng, C.-L., Scorpio, D.E. & Kibert, C.J. (1997). Strategies for successful construction and demolition waste recycling operations. *Construction Management & Economics* 15(1): 49-58.

Poon, C.S., Yu, A.T.W. & Ng, L.H. (2001a). A Guide for Managing and Minimizing Building and Demolition Waste. The Hong Kong Polytechnic University.

Poon, C.S., Yu, A T.W.Y. & Ng, L.H. (2001b). On-site sorting of construction and demolition waste in Hong Kong. *Resources, Conservation and Recycling* 32(2): 157-172.

Poon, C.S., Ann, T.W.Y., Wong, S.W. & Cheung, E. (2004). Management of construction waste in public housing projects in Hong Kong. *Construction Management & Economics* 22(7): 675-689.

Pun, K.F., Hui, I.K. & Lee, W.K. 2001. An EMS approach to environmentally-friendly construction operations. *The TQM Magazine* 13(2): 112-119.

Tam, C.M., Deng, Z.M., Zeng, S.X. & Ho, C.S. (2000). Quest for continuous quality improvement for public housing construction in Hong Kong. *Construction Management and Economics* 18(4): 437-446.

Tam, V.W.Y. (2008). On the effectiveness in implementing a waste-management-plan method in construction. *Waste Management* 28(6): 1072-1080.

Yahya, K. & Boussabaine, A.H. (2006). Eco-costing of construction waste. *Management of Environmental Quality: An International Journal* 17(1): 6-19.

Yip, J.S.L. (2000). New directions of environmental management in construction: accepted levels of pollution. *Structural Survey* 18(2): 89-98.

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Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

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