Australian Journal of Basic and Applied Sciences, 9(1) January 2015, Pages: 297-304

AENSI Journals
Australian Journal of Basic and Applied Sciences
ISSN:1991-8178

Journal home page: www.ajbasweb.com

Construction Waste Generation Factors throughout Construction Life Cycle – Case study of Peninsular Malaysia

Aftab Hameed Memon, Nor Solehah Md Akhir, Ismail Abdul Rahman, Sasitharan Nagapan

Faculty of Civil and Environmental Engineering, University Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, Malaysia.

ARTICLE INFO

Article history:
Received 19 September 2014
Received in revised form
19 November 2014
Accepted 22 December 2014
Available online 2 January 2015

Keywords:
Construction Waste
Was Factors
Construction Life Cycle

ABSTRACT

Background: Nowadays, the amount of construction waste generation is increased drastically. Malaysia also is facing with this problem. Construction waste has adverse effects on environment, social economic perspectives of a country. Thus, it is very essential to control the waste generation. This waste problem occurs in construction projects due to various factors which are required to uncover for effective control of the waste. For this, literature review highlighted 46 common factors of construction waste generation worldwide which are considered to investigate in Malaysian construction industry. **Objective:** The objective of this research is to identify the factors causing to construction waste generation in four phases of construction life cycle. **Results:** Interviews were conducted with 9 experienced personnel involved in handling and managing construction projects in Malaysia. The ranking of factors calculated through Average Index method showed that the factors have higher AI value in construction phase, followed by finishing phase, design phase and planning phase**. Conclusion:** The findings of the study have revealed major factors causing waste generation in construction project along various phases of the project. Further, the construction phases is found as the critical phase which indicated that the construction players have to pay more attention in order to lessen the generation of construction waste at site**.**

To Cite This Article: Aftab Hameed Memon, Nor Solehah Md Akhir, Ismail Abdul Rahman, Sasitharan, Construction Waste Generation Factors throughout Construction Life Cycle – Case study of Peninsular Malaysia. ***Aust. J. Basic & Appl. Sci.,*** *9(1): 297-304, 2015*

INTRODUCTION

Construction industry is constantly facing the crisis of construction waste generation. With the increasing in development, the amount of waste generated has increased drastically (Katz & Baum, 2011) especially it is more contributed in the urban area and tends to increase more (Nazech *et al*. 008). A research work conducted by (Kartam *et al*. 2004) highlighted that, Construction and Demolition (C&D) waste is generated at a rate of 1.6 million ton/year. In a study of Netherland construction industry, (Bossink & Brouwers, 1996) found that waste generation in construction projects are equal to 9% of the totally purchased materials. This generation of waste has negative impact to the environment, cost, productivity, time, social and economy of the industry (Osmani, 2012; Wang *et al*. 2008).

Together with other countries, Malaysia also is facing with the problem of construction waste which has resulted in illegal dumping. As reported by Begum and Pereira (2011), 80% of construction waste generated in the country is disposed at illegal dumpsite and only 20% of waste is disposed in legal landfills (Begum and Pereira, 2011). A case study consisting of two projects, carried out by Foo et al (2013) revealed that the waste generated at two sites of housing project was 154.31 m3 where major component of waste was timber (49%). This generation was waste is due to several factors. The behavior of waste generation varies at different stages of the project lifecycle. Only by controlling those source factors throughout the project lifecycle, the waste generation problem can be resolved. Hence, this paper focuses on identifying the factors causing construction waste generation at various phases of construction life cycle (CLC).

Literature Review:

Construction Life Cycle (CLC):

Construction life cycle refers to the whole process from creating the construction intention to abolishing the project, which includes the project decision-making stage, implementation stage and operation stage as cited by (Jiu-yan *et al*. 2009). Various researchers have classified project lifecycle in different phases. Traditional life cycle of a project includes several phases which are conceptual planning and feasibility studies, design and engineering, construction, and operation and maintenance (Kartam, 1996). (Liu *et al*. 2011) in their research

Corresponding Author: Aftab Hameed Memon, Faculty of Civil and Environmental Engineering, University Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor Malaysia.
Phone numbers: 0060-7-4564336

work, classified project life cycle into five stages which are preparation stage, design stage, pre-construction stage, construction and use stage, and post-construction stage. In this research work, construction life cycle is divided into four phases which are planning, design, construction and finishing as shown in Figure 1.

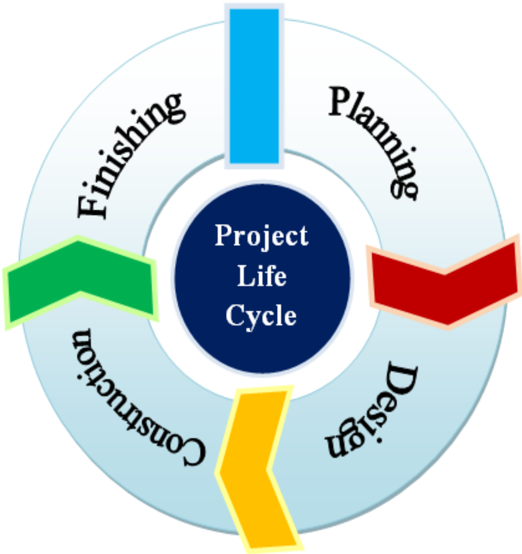

Fig. 1: Construction Life Cycle Diagram

In Construction Lifecycle, planning phase refers to stage where clients identify the requirements of each scope of work in construction project. The activities included in phase are defining the objective of project, estimation of preliminary cost, identifying funding source, clarifying any problem related to the project and suggesting alternative solution is provided. In design phase, designers prepare the detailed construction drawing, written contract conditions containing legal requirements, technical specifications and selecting the contractor. In construction phase, contractor is responsible for interpreting client requirements from drawings to real form according to specifications provided. Inspection and interpretation is also carried out by the engineer/architect to ensure the work is in right execution, safety implementation, quality control and less impact to environment. Finishing phase is the stage of project closure. The involved activities in this phase are determining whether all of the project completion criteria have been met, handing over project documentation to the owner, termination supplier contracts, releasing project resources and communicating the project closure to all stakeholder.

Factors of Construction Waste:

Construction waste impairs the efficiency, effectiveness, value, and profitability of construction activities. Hence, it is very vital to identify the causes of waste generation to control the waste generation. (Yunpeng, 2011) investigating the construction waste issue found that key reasons of waste generation are unimplemented waste management measures and weak consciousness of material saving and environmental protection, low performance of building materials and backward construction technologies, lack of communication and coordination between building contractors, no irritation of market benefit and short of supervision. In Singapore, a survey carried out by (Ekanayake and Ofori, 2004) highlighted that lack of attention paid to dimensional coordination of products, design changes while construction is in progress, designer's inexperience in method and sequence of construction and lack of knowledge about standard sizes available on the market, errors by trades persons or laborers, damage to work done due to subsequent trades and required quantity unclear due to improper planning are major factors of waste generation. Lack of effort in practicing minimizing waste strategy and conserving natural resources were regarded as main reasons of waste generation in Sri Lanka (Kulatunga et al. 2006). In order to identify the factors of construction waste generation, a comprehensive literature review was done and 46 common factors occurring worldwide were identified as listed in table 1.

Table 1: Factors of Construction Waste Generation

Information and Communication (ICT)		Delivery/Procurement	
1	Poor coordination between parties	25	Wrong material delivery procedures
2	Poor quality of information	26	Supplier errors
3	Delay in information flow among parties	27	Error in shipping
4	Delay due to too many interactions between various specialists	28	Difficulties for delivery vehicles accessing construction sites
Equipments		29	Delay during delivery
5	Unsuitable tools used	30	Damage during transportation
6	Shortage of equipment	31	Long waiting periods

Australian Journal of Basic and Applied Sciences, 9(1) January 2015, Pages: 297-304

7	Equipment failure	External/Unpredictable	
8	Non availability of equipment	32	Effect of accidents at site
9	Abnormal wear of equipment	33	Effect of weather
Project and Contract Management		34	Damages caused by third parties
10	Lack of legal enforcement	35	Delay due to Festival celebrations
11	Error in contract document	36	Unforeseen ground conditions
12	Last minute client requirements	37	Inappropriate lighting arrangement
13	Lack of waste management plan	Human Resource/Manpower	
14	Mistakes in quantity estimations	38	Interference of others crews at site
15	Inexperienced designer	39	Poor attitudes of workers
16	Over allowances paid lead to over budget	40	Damage caused by workers
17	Rework	41	Insufficient training for workers
Material		42	Lack of experience
18	Stealing at site	43	Lack of knowledge on construction
19	Vandalism at site	44	Poor workmanship
20	Poor quality of materials	45	Lack of enthusiasm among workers
21	Ordering errors	46	Workers exhausted because of too much overtime
22	Items not in compliance with specification		
23	Inventory of materials not well documented		
24	Inappropriate use of materials		

Data Collection And Analysis:

This study is carried out qualitatively by conducting structured interview with the experience personnel involved in handling and managing construction projects. Based on the identified factors, the respondents were asked about the level of occurrence of these factors in relative to Malaysian construction environment. Level of occurrence was measured based of five point likert-scale of 1 to 5 was adopted to assess the level of occurrence of each factor where 1 = not occur, 2 = slightly occur, 3 = moderately occur, 4 = often occur, 5 very often occur. Occurrence was assessed with Statistical Software Package SPSS using frequency and Average Index (AI) method calculated with formula adopted from (Memon *et al*. 2011). AI is calculated by using the following formula

$$AI = \frac{\sum(1X1 + 2X2 + 3X3 + 4X4 + 5X5)}{\sum (X1 + X2 + X3 + X4 + X5)}$$

Where;

X1 = Number of respondents for scale 1
X2 = Number of respondents for scale 2
X3 = Number of respondents for scale 3
X4 = Number of respondents for scale 4
X5 = Number of respondents for scale 5

Evaluation ranges to assess occurrence level was used in this study as follows:

$1.00 < AI < 1.50$: Not Occur
$1.50 < AI < 2.50$: Slightly Occur
$2.50 < AI < 3.50$: Moderately Occur
$3.50 < AI < 4.50$: Often Occur
$4.50 < AI < 5.00$: Very Often Occur

RESULTS AND DISCUSSION

The participants involved in interviews are experienced practitioners who are involved in construction industry for several years. The summary of the experience of the respondents is presented in figure 2.

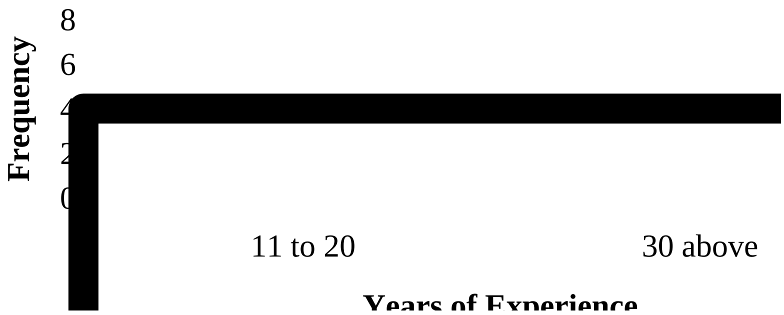

Fig. 2: Experience of the respondents participating in Interview

Australian Journal of Basic and Applied Sciences, 9(1) January 2015, Pages: 297-304

Figure s shows the frequency of the experience of the respondents. All the respondents involved in interviews have working experience for more than 10 years, among which 3 respondents are practicing in construction industry for more than 30 years. Average index value of each factor is shown in table 2.

Table 2: AI value and rank of each factor along each phase of CLC

No	Factors	Average Index			
		Planning	Design	Construction	Finishing
Information and Communication (ICT)					
1	Poor coordination between parties	2.6	2.2	3.2	2.8
2	Poor quality of information	2.2	2.6	3.0	2.4
3	Delay in information flow among parties	2.0	2.3	3.1	2.3
4	Delay due to too many interactions between various specialists	1.7	2.1	2.6	2.2
Equipments					
5	Unsuitable tools used	1.2	1.2	2.7	2.1
6	Shortage of equipment	1.4	1.6	2.6	2.0
7	Equipment failure	1.1	1.0	2.8	1.9
8	Non availability of equipment	1.0	1.0	2.3	2.0
9	Abnormal wear of equipment	1.0	1.1	2.1	1.8
Project and Contract Management					
10	Lack of legal enforcement	1.8	1.8	2.6	2.1
11	Error in contract document	1.8	1.9	2.1	1.9
12	Last minute client requirements	2.2	2.8	3.0	2.8
13	Lack of waste management plan	1.7	1.4	2.6	1.9
14	Mistakes in quantity estimations	2.3	2.0	2.4	2.1
15	Inexperienced designer	1.6	2.3	1.9	1.8
No	Factors	Average Index			
		Planning	Design	Construction	Finishing
16	Over allowances paid lead to over budget	1.8	1.9	2.6	2.0
17	Rework	1.7	2.0	2.9	2.8
Material					
18	Stealing at site	1.0	1.1	3.3	2.2
19	Vandalism at site	1.0	1.0	2.6	2.0
20	Poor quality of materials	1.0	1.0	3.0	2.8
21	Ordering errors	1.0	1.1	3.0	2.6
22	Items not in compliance with specification	1.0	1.0	3.0	2.6
23	Inventory of materials not well documented	1.7	1.7	2.4	2.0
24	Inappropriate use of materials	1.2	1.4	2.9	2.4
Delivery/Procurement					
25	Wrong material delivery procedures	1.4	1.4	2.3	1.9
26	Supplier errors	1.2	1.2	2.3	2.2
27	Error in shipping	1.1	1.1	2.1	1.7
28	Delay during delivery	1.2	1.1	3.2	2.8
29	Difficulties for delivery vehicles accessing construction sites	1.1	1.1	2.8	2.4
30	Damage during transportation	1.1	1.1	2.4	2.1
31	Long waiting periods	1.1	1.6	2.9	2.7
External/Unpredictable					
32	Effect of accidents at site	1.1	1.1	3.1	2.4
33	Effect of weather	1.1	1.1	3.9	3.4
34	Damages caused by third parties	1.1	1.2	2.3	2.0
35	Delay due to Festival celebrations	1.1	1.1	2.4	2.3
36	Unforeseen ground conditions	1.1	1.2	2.7	2.2
37	Inappropriate lighting arrangement	1.1	1.1	2.1	1.9
Human Resource/Manpower					
38	Interference of others crews at site	1.1	1.2	2.7	2.3
39	Poor attitudes of workers	1.6	2.0	3.3	3.0
40	Damage caused by workers	1.2	1.6	3.1	2.2
41	Insufficient training for workers	1.2	2.0	3.3	2.7
42	Lack of experience	1.9	2.3	3.3	2.8
43	Lack of knowledge on construction	1.4	1.6	3.2	2.8
44	Poor workmanship	1.4	1.6	3.8	2.7
45	Lack of enthusiasm among workers	1.6	1.7	2.8	2.3
46	Workers exhausted because of too much overtime	1.4	1.7	2.9	2.8

From table 2 it can be perceived that, in planning phase, ‘Poor coordination between parties’ is recorded as the highest AI value with 2.6 which shows that this factors is moderately occurring in this phase. While, the others factors is lower than 2.5. The result shows that 30 factors are ranked as not occur with AI value in range of 1.00 to 1.50. It means that most factors do not contribute to the construction waste generation during planning phase. In design phase, two factors are in level of moderately occur, 20 factors in level of slightly occur and 24 factors in level of not occur. Design phase also indicate that most factors does not occur in this phase. In construction phase, the highest value of AI recorded is 3.9 for the factor 'effect of weather'. There are two factors falling in level of often occur, 31 factors in level of moderately occur, and 13 factors fall in level of slightly occur. There are no factors in the level of not occur. In finishing phase, 15 factors are in level of moderately occur, and 31 factors are regarded as slightly occur. The summary of the factors based on AI value for showing the level of occurrence in various phases of construction life cycle is presented in table 3.

Table 3: Factors Affecting Construction Waste in Each Phase

AI Value		4.50 to 5.00	3.50 to 4.50	2.50 to 3.50	1.50 to 2.50	1.00 to 1.50
No of Factors in Each Phase	Planning	0	0	1	15	30
	Design	0	0	2	20	24
	Construction	0	2	31	13	0
	Finishing	0	0	15	31	0

Based on classification from table 3, the factors with AI from 2.50 and above i.e. occurrence level moderate to extreme are considered as factors commonly occurring in construction projects of Malaysia. With this, only 1 factor in planning phase, 2 factors in design phase, 33 factors in construction phase and 15 factors in finishing phase are listed as common factors of construction waste generation in each phase as presented in table 4.

Table 4: Common Factors in Phase

Phase	No	Factors
Planning	1	Poor coordination between parties
Design	1	Error in contract document
	2	Poor quality of information
Construction	1	Effect of weather
	2	Poor workmanship
	3	Stealing at site
	4	Poor attitudes of workers
	5	Insufficient training for workers
	6	Lack of experience
	7	Poor coordination between parties
	8	Delay during delivery
	9	Lack of knowledge on construction
	10	Delay in information flow among parties
	11	Effect of accidents at site
	12	Damage caused by workers
	13	Poor quality of information
	14	Last minute client requirements
	15	Poor quality of materials
	16	Ordering errors
	17	Items not in compliance with specification
	18	Rework
	19	Inappropriate use of materials
	20	Long waiting periods
	21	Workers exhausted because of too much overtime
	22	Equipment failure
	23	Difficulties for delivery vehicles accessing construction sites
	24	Lack of enthusiasm among workers
	25	Unsuitable tools used
	26	Unforeseen ground conditions
	27	Interference of others crews at site

	28	Delay due to too many interactions between various specialists
	29	Shortage of equipment
	30	Lack of legal enforcement
	31	Lack of waste management plan
	32	Over allowances paid lead to over budget
	33	Vandalism at site
Phase	No	Factors
Finishing	1	Effect of weather
	2	Poor attitudes of workers
	3	Poor coordination between parties
	4	Last minute client requirements
	5	Rework
	6	Poor quality of materials
	7	Delay during delivery
	8	Lack of experience
	9	Lack of knowledge on construction
	10	Workers exhausted because of too much overtime
	11	Long waiting periods
	12	Insufficient training for workers
	13	Poor workmanship
	14	Ordering errors
	15	Items not in compliance with specification

From table 4, it can be perceived that most factors are occur in construction phases which is followed by finishing phase, design phase and planning phase. These deductions are in accordance with the research findings by Osmani et al (2006) highlighting that, waste is primarily produced during site operation and rarely occurred during at the early stage. Waste may occur due to a number of different activities during construction, including excavated materials, site clearances, formwork and false work, materials and equipment wrappings, unusable or surplus cement/grouting mixes and damaged/surplus construction materials (Shen et al, 2004). From the findings, it is revealed that only one factor is listed as common factor in planning phase which is Poor coordination between parties. This factor also common in others phase which is in construction phase and finishing phase. This finding is in line with the findings from Wan et al (2009) where poor coordination between parties was found as main cause of construction waste at various stages include in planning phase, purchasing and subcontracting stage, material control stage, and site installation and testing and commissioning stage. This factor may lead to late information and last minute client requirements (Osmani *et al*. 2008). Hence, it may lead to material and cost waste (Garas *et al*. 2001).

The highest AI value in design phase is for the factor "Error in contract document". Error in contract document may cause confusion often arise then, lead to delays or error in the next work process. The delays and error may cause to material and time waste (Ekanayake and Ofori, 2004; Ling and Nguyen, 2013). In construction and finishing phases, the factor effect of weather is with the highest value of AI and is recorded as the highest value among all the factors. Bad weather may spoil many construction materials at site and cause material damage. Thus, the material cannot perform well and ends up as materials waste. Bad weather also may cause delay of some construction activity at site such as concreting and excavation work will be disturbed due to heavy rain and storm (Nagapan *et al*. 2012).

Conclusion:

Construction waste is common issue worldwide occurring throughout the construction lifecycle of a project. The occurrence of waste is due to several factors having different level of occurrence in various phases. This study identified a total of 46 factors were identified through literature review which were considered for investigation for assessing level of occurrence in Malaysian construction projects. Investigation involved interviewing 9 experience construction players, for determining factors occurring into four phase's i.e. planning, design, construction and finishing. The result showed that 1 factor occur in planning phase, 2 factors occur in design phase, 33 factors occur in construction phase and 15 factors occur in finishing phase. This demonstrates that construction phase is the most critical phase in CLC where most of the factors occur. The result also showed effect of weather is the highest AI value among others factors which occurs in construction and finishing phase. These finding provide a basis for further investigation of assessing level of risk of each factor.

ACKNOWLEDGEMENT

The authors would like to thank Universiti Tun Hussein Onn Malaysia for supporting this study under FRGS 1222. Also, we are thankful to construction practitioners for providing comprehensive and important information, and a lot of cooperation which made data collection easier. Further, Aftab Hameed Memon is thankful to the Quaid-e-Awam University of Engineering, Science and Technology also for granting permission to carryout research work at Universiti Tun Hussein Onn Malaysia.

REFERENCES

Begum, R.A., J.J. Pereira, 2011. C & D Waste Profile Of The Malaysian Construction Industry: Need A Centralized Database. IEEE, World Congress on Sustainable Technologies (WCST):73-76.

Bossink, B.A.G., H.J.H. Brouwers, 1996. Construction Waste: Quantification And Source Evaluation. Journal Of Construction Engineering And Management, 122(1): 55-60.

Ekanayake, L.L., G. Ofori, 2004. Building Waste Assessment Score: Design-Based Tool. Building And Environment, 39(7), 851-861.

Foo, L.C., I.A. Rahman, A. Asmi, S. Nagapan, K.I. Khalid, 2013. Classification And Quantification Of Construction Waste At Housing Project Site. International Journal Of Zero Waste Generation, 1(1): 1-4.

Jiu-Yan, W., S. Yi-Kun, T. Jin-Xin, 2009. Study On The Construction Project Life-Cycle Integrated Management System. 16th International Conference On Management Science & Engineering: pp: 1976-1981.

Kartam, N.A., 1996. Making Effective Use Of Construction Lessons Learned In Project Life Cycle. Journal Of Construction Engineering And Management, 122: 14-21.

Kartam, N., N. Al-Mutairi, I. Al-Ghusain, J. Al-Humoud, 2004. Environmental Management Of Construction And Demolition Waste In Kuwait. Waste Management, 24(10): 1049-59.

Katz, A., H. Baum, 2011. A Novel Methodology To Estimate The Evolution Of Construction Waste In Construction Sites. Waste Management, 31(2): 353-358.

Kulatunga, U., D. Amaratunga, R. Haigh, R. Rameezdeen, 2006. Attitudes and perceptions of construction workforce on construction waste in Sri Lanka. Management of Environmental Quality: An International Journal, 17(1): 57-72.

Garas, G.L., A.R. Anis, A. El. Gammal, 2001. Materials Waste In The Egyptian Construction Industry, Proceedings of International Conference of Lean Construction Group, IGLC-9: 1-8.

Ling, F.Y.Y., D.S.A. Nguyen, 2013. Strategies for construction waste management in Ho Chi Minh City, Vietnam, Built Environment Project and Asset Management, 3(1): 141-156.

Liu, Z., M. Osmani, P. Demian, A.N. Baldwin, 2011. The Potential Use Of BIM To Aid Construction Waste Minimisation. Proceedings Of The CIB W78-W102 2011: International Conference –Sophia Antipolis, France, 26-28 October.

Memon, A.H., I.A. Rahman, A. Asmi and A. Azis, 2011. Preliminary Study On Causative Factors Leading To Construction Cost Overrun. International Journal Of Sustainable Construction Engineering & Technology, 2(1): 57-71.

Nagapan, S., I.A. Rahman, A. Asmi, 2012. Factors Contributing To Physical And Non-Physical Waste Generation In Construction Industry, 1(1).

Nazech, E.M., D. Zaldi, B. Trigunarsyah, 2008. Identification Of Construction Waste In Road & Highway Construction Projects. Proceedings Eleventh East Asia-Pacific Conference On Structural Engineering And Construction (EASEC-11): 1-7.

Osmani, M., 2012. Construction Waste Minimization In The UK: Current Pressures For Change And Approaches. Procedia - Social And Behavioral Sciences, 40: 37-40.

Osmani, M., J. Glass, A.D.F. Price, 2008. Architects' Perspectives On Construction Waste Reduction By Design. Waste Management, 28(7): 1147-1158.

Osmani, M., J. Glass, A. Price, 2006. Architect And Contractor Attitudes To Waste Minimisation. Proceeding Of Institution Of Civil Engineering, Waste And Resource Management, 159(WR2): 65-72.

Shen, L.Y., V.W.Y. Tam, C.M. Tam, D. Drew, 2004. Mapping Approach For Examining Waste Management On Construction Sites. Journal Of Construction Engineering And Management, 130(4): 472-481.

Wan, S.K., M.M. Kumaraswamy, D.T. Liu, 2009. Contributors To Construction Debris From Electrical And Mechanical Work In Hong Kong Infrastructure Projects. Journal Of Construction Engineering And Management, 135(7): 637–646.

Wang, J.Y., X.-P. Kang, V.W.Y. Tam, 2008. An Investigation Of Construction Wastes: An Empirical Study In Shenzhen. Journal Of Engineering, Design And Technology, 6(3): 227-236.

Australian Journal of Basic and Applied Sciences, 9(1) January 2015, Pages: 297-304

Yunpeng, H., 2011. Minimization management of construction waste, International Symposium on Water Resource and Environmental Protection (ISWREP), China: 2769–2772, Retrieved from http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=5893453