Preliminary Study on Waste Management for Implementation of Green Highway

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Abstract

Green highway is the transportation corridors which based on relatively new concept of roadway design. It incorporates both transportation functionality and ecological requirements. Green highway also provide more sustainable construction technique that maximize the lifespan of highway. Waste management is one of the importance criteria in the elements of green highway. This is because, management of construction waste is becoming a pressing problem worldwide. There is a need to reduce the amount of waste production, reduce the cost for managing the waste as well as saving the environment. This paper aims to identify the criteria of waste management in development of green highway. This is exploratory study focus only on green highway. Preliminary study was done using quantitative method. 30 sets of questionnaires have been distributed to highway construction experts. The data was analyzed using Statistical Packages for Social Science (SPSS). The results from the analysis shows wood is the highest production of waste and reused back the material is the best way to minimize the waste.

Keywords: Green highway, Waste minimization, Waste Management.

1.0 Introduction

As a developing country, development of green highway is encouraged (Bryce, 2008). Green highway development are includes design of highwayin such a manner that improves the quality of nation's infrastructure (Bryce, 2008).With the demands in implementation of major infrastructure projects in Malaysia, together with the commercial and housing development, a large amount of construction waste is being produced by the construction sector (Begum, Siwar, Pereira, & Jaafar, 2007). Construction sector generates large amount of waste and contributes to the environmental problem (Wokekoro, 2007). The construction waste become as issues that needs highly concern in many developing countries because it has an adverse effect on economy, environment and social aspects.

According to GEC (2012), solid waste is one of the three major environmental problems in Malaysia. Over 23,000 tonnes of waste is produced each day in Malaysia. The amount of solid waste is expected to rise to 30,000 tonne by the year of 2020 (GEC, 2012). In Malaysia, there are almost 1800 rivers, but more than half of the rivers have been polluted and destroyed because of the improper solid waste management (GEC, 2012). The management of solid waste is importance to reduce or eliminates the adverse impacts on the environment and human health.

2.0 Literature Review

2.1 Waste

Waste can be defined as material of solid or semi-solid character that the possessor no longer considers of sufficient value to retain (Wokekoro, 2007). Formosa et al. (2002) stated waste as a wastage sources likes material, time (labor and equipment) and capital cost due to the activity directly or indirectly, but not for the better or value of the final product according to customer satisfaction.Waste is all waste arising from human and animal activities that are normally solid and that are discards as useless or unwanted (Tchonobouglous,Theisin, & Vigil, 1993). According to Pitchel (2005), waste is a material possessing a negative economic value, which suggest that is cheaper to discard than to use.Therefore, waste should be defined as any losses in material, time and monetary

result by activities but do not add value or progress to the product, which can be eliminated without reducing customer value.

2.2 Category and sources of waste

Different author have their own category and sources of waste. Pitchel (2005) stated nine categories of waste such as municipal, hazardous, industrial, medical, universal, construction and demolition, radioactive, mining and agriculture waste. While, Bai&Sutanto (2002) divide categories of waste to three which are domestic refuse, industrial and institution waste. While for the sources of waste, have many sources of waste as listed in table 1 according to author.

Table 1: Sources of waste

Author	Tchonobouglous et al. (1993)	Pitchel (2005)	Wokekoro (2007)
Sources of waste	a. Commercial b. Institutional c. Construction and demolition d. Municipal service (excluding treatment plant sites) e. Treatment plant sites (municipal incinerators) f. Municipal solid waste g. Industrial h. Agriculture	a. Municipal – residential, commercial, institutional, industrial, municipal b. Hazardous – manufacture, electroplating, metal treating, wood preserving and petroleum refining c. Industrial – manufacturing d. Medical – hospital, physicians, dentists, veterinarians, healthcare facilities, clinics, laboratories, blood banks and funeral homes e. Universal – small and large business, household f. Construction and demolition – construction, renovation and demolition g. Radioactive – specializes of industrial waste, research and medical h. Mining – physical removal of desired resources i. Agriculture – animal manures and crop residues	a. Municipal – street sweeping, sewage, waste form schools, market and other institution b. Domestic – garbage, rubbish and large waste from homes c. Commercial – stores and offices d. Industrial – manufacturing plants e. Mining – coal mining, strip mining etc
	Bai&Sutanto (2002)	ONSW (2012)	Environment Strategies (2000)
	a. Domestic - solid waste from household, markets, food center and commercial premises b. Industrial – not including toxic and hazardous c. Institution – solid waste from government and board	a. Household b. Commercial c. Construction and demolition d. Industrial e. Institution f. Public imported	a. Residential b. Industrial c. Commercial d. Instituted e. Construction and demolition f. Municipal g. Manufacturing h. Agriculture

2.3 Waste Management

Based on Basri& Ahmad Basri (2008), waste management is an integral part of urban and environmental management of each city. Waste management is a major challenge for Malaysia to address in the light of vision 2020 which lays out of direction for Malaysia to become a fully developed nation by 2020 (UNDP, 2008). Waste management are designed to prevent or reduce the discharge of pollutants to storm water from solid or construction waste by providing designated waste collection areas and containers, arranging for regular disposal, and training employees and subcontractors (CASQA, 2003).

According Pitchel (2005) waste management is concerned with the generation, on site storage, collection, transfer, transportation, processing and recovery, and ultimate disposal of solid wastes. Tchobanoglous et al.(1993) defined waste management as the discipline associated with the control of generation, storage, collection, transfer and transport, processing, and disposal of solid wastes in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics, and other environmental considerations, and that is also responsive to public attitude.

As to conclude, waste management is a management process to ensure waste generated will be treat in the right way. It aims to reduce the production of waste and to reduce the amount of waste going to landfill. It also to reduce the environment problem that become a major problem nowadays.

2.4 Waste Minimization

Environmental Protection Agency (EPA) of United States (2000) defined waste minimization as any method that reduces the volume or toxicity of a waste that requires disposal. It is any method that reduces the amount of waste. Government regulations, as well as internal cost effectiveness, require that the production and therefore the disposal of all wastes, and particularly hazardous wastes, be kept to a minimum. Waste minimization is defined by Poon, Ann, &Jaillon (2004) as any technique, process or activity which avoids, eliminates or reduces waste at its source or allows reuse or recycling of the waste. Figure 1 shows the waste management hierarchy by Poon &Jaillon (2002). It starting with prevention, reduction at source, reuse of product, quality improvements, recycling, energy recovery and pre-treatment.

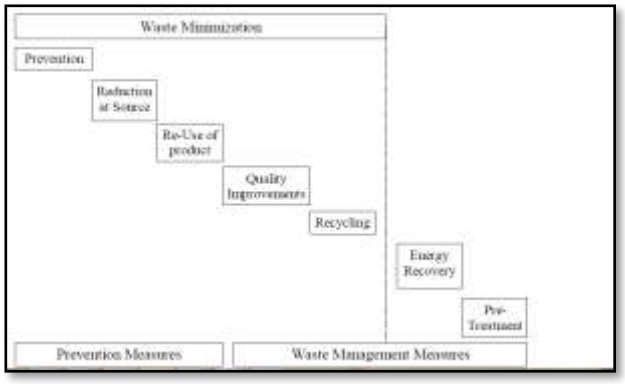

Figure 1: Waste minimization hierarchy. Copyright, Poon et al. (2004)

Faniran&Caban (1998) wrote there are have three main waste minimization strategies which are avoiding waste, reusing materials and recycling waste. Avoiding waste refer to any practice or process that avoids, eliminates or minimizes waste at the source. Meanwhile, reusing and recycle waste are reusing and recycling of materials whereby reducing the volume of waste material to de disposed of and discharged into environment. They proposed waste management hierarchy that consist of avoid, reuse, recycle and disposal as shown in figure 2 below.

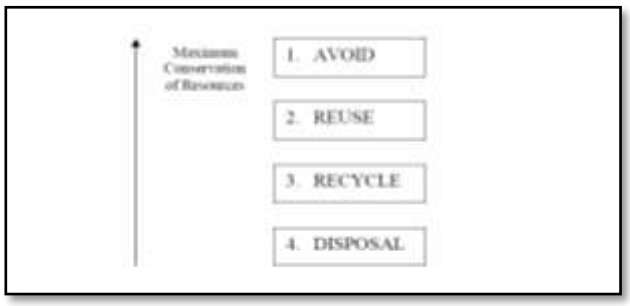

Figure 2: Waste minimization hierarchy. Copyright, Faniran&Caban (1998)

2.4 Waste Management Plan

Macozama (2002) defined waste management plan as a plan that consist of prevention, isolation, repair, reuse, recycle and also disposal of waste. The main objective of waste management plan is reduce, reuse, and recycle of waste (Bruce &Smitchers, 1998). Moreover, Macozama (2002) has identify the good management plan which are goals, waste audit, waste handling requirement, waste disposal, transportation and economic evaluation. Meanwhile, Lim& Ling (2002) has categorize the element of waste management plan to 4 categories which are prevention of waste, reduction, recycle and administration. A good waste management plan will help to reduce amount of waste going to landfill and reduce the cost of management the waste.

3.0 Review

In this section, explaining what is used to conduct this study. For categories and sources of waste follow from Pitchel(2005). The reason using Pitchel(2005) because he clearly stated the categories and sources of waste. The categories is divide to municipal, hazardous, industrial, medical, universal, construction and demolition, radioactive, mining and agriculture. For this study, the category related is construction and demolition. Then, the sources of waste comes from highway itself.

For waste minimization, the hierarchy has been chosen from Poon et al. (2004). It is not only focus to the basic waste minimization such as prevent, reuse, recycle and disposal. It consist of prevention, reduction at source, reuse of product, quality improvement, recycling, energy recovery and pretreatment. This waste minimization hierarchy guide people to choose the best way how to manage the waste correctly.

4.0 Result & Findings

4.1 Types of waste

Table 2 below shows the average index for waste produce during the construction and demolition of highway.The formula of average index is taken from study by Al-Hammad&Assaf (1996). Below (1) is the formula for calculation of average index. 1, 2, 3, 4 & 5 present for scale, where X1 until X5 is number of respondent for every scale. ‘n’ present for total number of sample.

$$\text{Average index} = \frac{\sum a1x1}{\sum x1}$$

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

The waste involve are tree root or stump, soil, concrete, asphalt, wood, metal, rock, aggregate, sand, crusher run, bituminous, and premix. The top ranking of production of waste are wood, followed by soil, tree root or stump, sand and concrete. Whereas, the lowest rank is metal. The highest rank of waste is wood 3.333 average. Wood is always used as a temporary support especially for concreting work. Nature of wood that easy to rot also become one of reason why wood is the highest production. It support by study of Lachimpadi et al. (2012) also found wood is the largest quantity of construction waste.

The second ranking is soil 3.267 average.Different site will produced different quantity of soil. It depends on condition of sites whether it needs to be cut or filled to get a flat ground before construction could begin. Lachimpadi et al. (2012) concludes that the generation of soil waste greatly depended on the design and the landscape of the site. If the site at hilly area, it will involve a lot of cutting compared to fills. Thus the surplus of soil will classified as soil waste. in study by Begum et al. (2006) also found that soil and sand is the second highest for their study worth percentage (27%).

Metal got the lowest ranking with 2.467 average. Metal become the lowest production because of the limited usage in construction of highway. In addition, the metal is the custom made from the factory. It will deliver to site according to the quantity order. According to TechnologiyaMetallov (2008), in Russia the production of metal waste is also low.

Table 2: Average Index for types of waste produce.

Bill	Types of waste produce	1 Freq	2 Freq	3 Freq	4 Freq	5 Freq	Total frequency a1x1	Average Index	Ranking
	Construction and demolition Waste								
1	Tree Root / Stump	0	6	12	12	0	96	3.200	3
2	Soil	0	10	6	10	4	98	3.267	2
3	Concrete	2	10	10	4	4	88	2.933	4
4	Asphalt	2	12	12	4	0	78	2.600	9
5	Wood	0	4	12	14	0	100	3.333	1
6	Metals	2	16	8	4	0	74	2.467	12
7	Rock	0	10	14	6	0	86	2.867	6
8	Aggregate	2	8	12	8	0	86	2.867	6
9	Sand	0	10	12	8	0	88	2.933	4
10	Crusher Run	2	8	12	8	0	86	2.867	6
11	Bituminous	2	12	14	2	0	76	2.533	11
12	Premix	2	12	12	4	0	78	2.600	9

4.2 Waste Minimization Strategy

For waste minimization strategy, it is used to know the best way to minimize the waste. The strategy of waste minimization consist of C1 = Prevention, C2 = Reduction at Source, C3 = Reuse of Product, C4 = Quality Improvement, C5 = Recycle, C6 = Energy Recovery, C7 = Pre-treatment and C8 = Disposal. The data received was analyzed using percentage.

Table 3shows the percentage for waste minimization strategy. Tree root and stump shows recycle is the highest percentage for waste minimization. It is a good practice where the tree root and stump can be recycle and produce something else such for garden decoration. According to Suez Environment (2015) the tree root and stump are difficult to process. So, people always recycle the tree root and stump and make decoration at garden until unique root art decorations can impress and amaze people see it.

While, for all types of waste other than tree root and stump, highest percentage of waste minimization is reused. The waste are soil, concrete, asphalt, wood, metals, rock, aggregate, sand, crusher run, bituminous and premix. All the material can be reused back for other project and function. It is because the material is raw material and will not damage except for wood. Wood after the several times reused it cannot be used again. After reused, wood will be disposed to the landfill.

Table 3: Percentage of waste minimization strategy.

Bill	Types of Waste	C1 %	C2 %	C3 %	C4 %	C5 %	C6 %	C7 %	C8 %
	Construction & Demolition Waste								
1	Tree Root / Stump	5	10	0	10	**30**	0	20	25
2	Soil	6	6	**71**	0	0	0	6	12
3	Concrete	0	6	**67**	0	0	0	22	6
4	Asphalt	0	13	**75**	6	0	0	6	0
5	Wood	5	5	**53**	5	11	0	5	16
6	Metals	0	6	**71**	6	0	0	18	0
7	Rock	0	6	**72**	0	22	0	0	0
8	Aggregate	0	6	**76**	0	12	0	0	6
9	Sand	0	6	**81**	0	6	0	0	6
10	Crusher Run	0	6	**75**	6	6	0	0	6
11	Bituminous	0	13	**63**	0	6	0	13	6
12	Premix	0	13	**56**	0	6	0	19	6

4.3 Waste Management Plan

This data set show Cronbach's Alpha is 0.946 with 11 variables. There is high internal consistency for the data set which the Cronbach's Alpha is more than 0.7. (Hair et al. 2010).The data received from the waste management plan was analyzed using Relative Importance Index (RII). This method to determine the relative importance of the waste management plan. The formula of relative importance index as stated below (2) from Kometa et al. (1994). Where W = weights given to each factor by the respondents and will ranges from 1 to 5 where '1' is strongly disagree and '5' is strongly agree. A = highest weight (i.e. 5 in this case), and N = total number of respondents. The higher the index value close to 1 means that the higher the position of the statement.

$$RII = \frac{\sum w}{AN} \quad (2)$$

In table 4 shows from 11 factor of waste management plan shows the highest RII is 0.893 are provide strategic management plan, organize waste and suggestion for improvement. Then, policy regarding waste management, employees with responsibility to manage waste and management of waste share same RII 0.867. Identifying the type of waste, measure and audit, and review plan also have same RII 0.840. RII 0.827 is training employees and last is record quantity of waste with RII 0.747.

From the analysis shows that there is awareness among people to manage waste. From this study also found the first ranking of important plan is strategic management plan. It supported by Mahayuddin (2011), all the construction site have doing plan to manage and minimize the waste. Besides that, organize waste also often practice by user. It consist of separation the waste by type of waste and how to manage the waste.

Record the quantity of waste is the lowest relative importance index 0.747. Record the quantity of waste is scarcely done. It same with study of Mahayuddin (2011), the recording of production of waste is the lowest practiced where from 10 sites only 2 practice record the waste. Hence, the act of recording waste production needs to be practiced more so the actual amount of waste produced can be known, and can be reduced for any upcoming projects.

Table 4: Relative Importance Index for Waste Management Plan.

Bill	Waste Management Plan	Total weight of statement ∑w	Relative Importance Index (RII)	Ranking
1.	Provide strategic management plan	134	0.893	1
2.	Organize the waste	134	0.893	1
3.	Suggestion for improvement	134	0.893	1
4.	Policy regarding waste management	130	0.867	4
5.	Employees with responsibility to manage waste	130	0.867	4
6.	Management of waste	130	0.867	4
7.	Identifying the type of waste	126	0.840	7
8.	Measure & audit	126	0.840	7
9.	Review Plan	126	0.840	7
10.	Training employees	124	0.827	10
11.	Record the quantity of waste	112	0.747	11

5.0 Conclusion

This study is a preliminary study of waste management for implementation of green highway. In this study found the types of waste produce by construction of highway. It also found the waste minimization strategy and the best way to manage the waste. This study found the most production of waste is wood and the lowest production is metal. Then, the best way to minimize the production of wood is reused. Whereas, for waste management, the practice of recording the quantity of waste must be improved. The function of record the quantity of waste is to know the actual amount of waste produce. Moreover, the best ways to minimize the waste also can be identified.

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