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# Perception on benefits of construction waste management in the Singapore construction industry

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## Abstract

**Purpose** – Increased disposal costs and reduction in number of landfills have created a need for implementing effective waste management in the construction industry. As every construction project is unique in its way of development, benefits from the waste management may also differ from project to project and thus project characteristics should be taken into consideration when implementing the strategy. This study seeks to investigate how different project characteristics affect perception on benefits, from construction waste management, based on the survey results from 66 industry experts.

**Design/methodology/approach** – A literature review was conducted to gather information on project characteristics and its classification, construction waste management, waste management plan and its benefits. Subsequently, a set of questions was formulated to gain insight and opinion on the selection of project characteristics and particular benefits of construction waste management. A set of questions pertaining to different project characteristics linked with benefits of waste management was sent to each of the personnel for their views.

**Findings** – The results of this study establishes that the key materials used in projects, project size in terms of total installed costs, and project type have perceptual impacts on benefits from construction waste management.

**Originality/value** – Understanding how project characteristics will affect the benefits can help the construction industry to identify projects to which the waste management should first be applied, maximizing its benefits.

**Keywords** Waste management, Project characteristics, Construction projects, Construction management, Singapore

**Paper type** Research paper

## Introduction

The construction industry produces substantial amount of waste, which is about four times of that produced in households thereby accounting for more than 50 per cent of the waste deposited in a typical landfill (Ferguson *et al.*, 1995; Coventry and Guthrie, 1998). Rising disposal costs and reduction in number of landfills create a need to search for alternatives to reduce, reuse and recycle construction waste being generated. Under this assertion, implementation of construction waste management can be one of the apparent solutions for the industry to minimize waste and waste disposal, ultimately reducing costs incurred during the process and contributing to the global “Environmental-friendly” movement.



Construction projects implementing waste management plans may generate favorable results with various benefits. However, in spite of substantial information showing benefits of implementing waste management in construction projects, there was an absence of information illustrating how benefits of waste management can be affected by different project characteristics. A possible reason is that every construction project is unique and thus apples-to-apples comparisons may be infeasible. This may further be attributed to difficulty in gauging the relationship between project characteristics and their benefits. However, the perception that project characteristics may have impacts on the benefits cannot be overlooked. As a result, this study aims to identify how project characteristics affect the benefits from construction waste management. More specifically, objectives of this study are:

- to explore major benefits of waste management; and
- to evaluate the perceptual impacts of projects characteristics on the benefits.

An intensive literature review was first carried out on construction waste management to provide relevant background information for this study and most importantly, to establish different characteristics of construction projects and determine the benefits of waste management. Then, a survey was conducted to find out professionals' opinions and perspectives towards the impacts. A total of 66 professionals consisting of project managers, contractors, quantity surveyors, site supervisors and consultants participated in the survey.

## Background

### *Construction waste management*

According to Bilitewski *et al.* (1994) and Gilpin (1996) waste management encompasses collection, transporting, storage, treatment, recovery and disposal of waste, and is defined as a comprehensive, integrated, and rational system approach towards achievement and maintenance of acceptable environmental quality and support of sustainable development. In addition, Minks (1994) regarded waste management as a tool for controlling disposal costs of construction waste, as well as facilitating examination of other alternative disposal methods such as recycling and reusing in order to reduce waste that finally results in landfills. The European Environment Information and Observation Network (EIONET) also defined waste management plan as a "strategic document drawn up for achieving the objectives of waste management and waste prevention and recovery", adding a limitation of the environmental impact of waste on human health and the environment (European Environment Information and Observation Network (EIONET), 2006).

The waste management hierarchy developed by El-Haggag (2007) is a useful framework and serves effectively as a guide while developing waste management plans. The framework works for providing an integrated approach in which options of waste management can be considered and thus serves as a systematic tool for those who generate and manage waste. There are five major steps in the structure:

- (1) Reduce.
- (2) Reuse.
- (3) Recycle.

- (4) Recover.
- (5) Disposal.

More details on the framework are explained in the research documented by El-Haggar (2007) and Greenwood (2000).

When waste management is properly implemented based on the framework, it can generate various benefits through the whole lifecycle of the waste from its generation to its final disposal. According to El-Haggar (2007), proper construction waste management will provide economic benefits by decreasing the cost of the project through proper implementation of a waste management plan. Apart from economic benefits, waste management may positively contribute to the following aspects (Crittenden and Kolaczkowski, 1992; Cunningham, 2001; Guthrie and Mallett, 1995; Guthrie *et al.*, 1997; McGrath, 2001; Tam *et al.*, 2007; Telford, 1995):

#### *Cost saving and profit maximization*

An increased emphasis on waste reduction, reuse and recycling may produce favorable outcomes such as cost saving. Unnecessary purchase of new construction materials that may be substituted by reused or recycled ones results in additional costs. In addition, generating less waste from construction projects results in reduction in disposal costs and landfill charges; eventually cutting down the total project costs. Furthermore, the cost saving, in turn, can maximize profit.

#### *Reduced demand for landfill spaces*

Minimizing the amount of waste sent to landfills for disposal can lead to less demand for landfill and reduction of negative environmental effects such as noise, pollution effects of landfill as well as emission and residues from incinerators.

#### *Improved resource management*

Waste management also involves planning and control of resources committed to projects in order to control the amount of waste generated. Therefore, better control of resources may be achieved with reduction in waste as well as improvement of entire resource management performance.

#### *Image improvement*

Implementing waste management as a company policy may allow companies to enhance their public images as “environmental-friendly companies” enhancing their impression on clients.

#### *Productivity and quality improvement*

Productivity can be improved by avoiding delays caused by reordering and repurchasing of materials that have been wasted once. By selecting material of good quality and durability, significant amount of waste generation caused by replacement of poor quality material during the life cycle of facilities can be avoided.

As reviewed previously, there are numerous benefits of implementing waste management. By exploring how different project characteristics affect these benefits allows the construction industry to understand the association between them.

### Characteristics of construction projects

The fundamental nature of a project is “temporary endeavor undertaken to create a unique product, service, or result” (PMBOK, 2004), implying that every building is distinctive. However, there may be characteristics in construction projects that can be categorized and that affect perception on implementation and benefits of waste management. Classification of construction projects depends on the purpose of research and its ability to produce appropriate research results. For this study, the characteristics of construction projects are classified into the following main categories and among the six categories, key characteristics of construction projects affecting perception on benefits of waste management will be further discussed later in the subsequent sections:

#### *Project size*

Construction projects can be categorized based on total project cost and four different categories are employed for this study: \$5 million and below, between \$5 to \$15 million, between \$15 to \$50 million, and \$50 million and above.

#### *Project nature*

Projects can be grouped according to their nature namely, residential, commercial, infrastructure and institutional. Residential projects include residential buildings intending to provide lodging to people. Commercial projects include office buildings and shopping malls for business purposes. Infrastructure projects involve constructing tunnels, railways and even roads with infrastructure nature. Institutional projects include schools and religious buildings.

#### *Project type*

Three types of construction projects identified are construction, renovation and demolition. In 1998, the US Environmental Protection Agency (EPA) estimated that 136 million tons of building-related waste is generated in the US annually, which is 25 to 40 per cent of the national solid waste stream. A 2003 update shows an increase to 164,000 million tons annually, of which 9 per cent is construction waste, 38 per cent is renovation waste, and 53 per cent is demolition debris (Napier, 2008). Hence, different types of projects are expected to have different impacts on benefits of waste management plan.

#### *Duration of project*

Duration of a construction project has a direct relationship with the duration of time that waste management can be implemented. Therefore, it is one of the characteristics that need to be explored.

#### *Key materials used in project*

Steel and concrete are considered principle resources for construction projects. Steel can be recycled repeatedly without any degradation in terms of properties or performance in quality. Steel construction has excellent low waste credentials during building life cycle and generates very little waste (Building and Construction Authority (BCA), 2007). Therefore, there is virtually little waste from steel products on construction site. Although concrete from construction, renovation and demolition can

be recycled, there is difficulty in separating aggregates for reuse in new structural concrete components (Building and Construction Authority (BCA), 2007). This shows that there is definitely an impact on benefits of waste management depending on the key material used in projects (Tam *et al.*, 2007).

**Research methodology**

An extensive literature review was conducted to gather information on project characteristics and its classification, construction waste management, waste management plan and its benefits. Subsequently, a set of questions was formulated to gain insight and opinion on the selection of project characteristics and particular benefits of construction waste management and was sent to each of the personnel for their views. The objectives of the survey were:

- to identify the key benefits for implementing waste management in construction projects;
- to collect respondents' views on whether project characteristics have effects on the benefits; and
- to gather respondents' views and insights of other project characteristics that will affect the benefits.

Both close-ended and open-ended questions were adopted in the survey that was divided into two sections. Section A consisted of general questions to identify the profile of respondents and Section B aimed to find out the experts' views and opinions, which allow experts to state their views on whether project characteristics affect benefit of waste management as well as to suggest any other project characteristics. The survey questionnaire is included in Appendix (see Figure A1).

About 300 questionnaires were sent out and 66 industry experts responded to the survey questions and they were mainly project managers, assistant project managers, contractors, quantity surveyors, clerk-of-work and site supervisors as shown in Table I.

	Respondent characteristics	No. of respondents (total = 66)	(%)
Designation	Project manager	10	15.2
	Assistant project manager	12	18.2
	Contractor	7	10.6
	Clerk of work	9	13.6
	Quantity surveyor	13	19.7
	Site supervisor	15	22.7
Years of experience	0-5	22	33.3
	6-10	14	21.2
	11-15	12	18.2
	16-20	11	16.7
	20 and above	7	10.6
Familiarity with subject	Very familiar	0	0
	More familiar	24	36.4
	Familiar	36	54.5
	Less familiar	6	9.1
	Not familiar	0	0

**Table I.**  
Summary of respondents

Waste management for construction projects may not be performed without the identified key personnel and their opinions would play a critical role to identify perception of key players on benefits from waste management. Overall, there is a fairly good mixture of designation of respondents, which would provide a fine basis for analyzing their views on this study. Having different years of experience in construction industry will have relationship towards to reliability of the responses and about 67 per cent of the respondents have more than six years of experiences in the construction industry. For the purpose of this study, it's important to identify respondents' level of familiarity with waste management as the respondents are supposed to provide their views on whether project characteristics will affect the benefit of waste management. As shown in Table I, 0 per cent for the option of not familiar and only 9 per cent for less familiar with waste management. Almost 91 per cent of the respondents were familiar and more familiar with waste management. This may indicate that opinions and suggestions from the respondents are of value and appropriate to be analyzed in context of waste management. The results from the survey were then collated to examine the validity of a hypothesis that characteristics of construction projects have impact on perception on benefits from waste management. The results will be provided and discussed in the following sections.

### Survey results and discussions

#### *Important benefits of waste management*

For this question, respondents were asked to give their views on the most important benefits offered by waste management. Out of 66 respondents, 26 respondents (39.4 per cent) chose cost saving as the most important benefit, followed by profit maximization (22 respondents; 33.3 per cent) as shown in Table II. In other words, financial benefits such as cost saving and profit maximization are first recognized as waste management benefits, contributing to almost 73 per cent of the responses from the 66 experts. This can be interpreted that more respondents are concerned about the financial benefits before they consider whether to implement waste management in their organizations. According to the interview conducted for this study, in construction companies, cost reduction is one of the top priorities and they believe that reducing waste can contribute to the cost reduction, maximizing profit. This may provide a base for the selection of financial benefits as the most important benefit appreciated by implementing waste management into the projects.

Furthermore, the survey result identified that although cost saving is one of the benefits to consider, image improvement, better resource management and improved productivity are also considered benefits from waste management. This indicates that

Construction waste management benefits	No. of respondents (total = 66)	(%)
Cost saving	26	39.4
Reduced demand for landfill spaces	1	1.5
Improved resource management	2	3.0
Profit maximisation	22	33.3
Quality improvement	4	6.1
Image improvement	5	7.6
Productivity improvement	6	9.1

**Table II.**  
Construction waste  
management benefits

there are usually multiple benefits to be taken into consideration while choosing whether to implement waste management plan in an organization. It is, however, of interest that the benefit, “Reduced demand for landfill spaces” was selected by only one respondent. According to *The Straits Times* (2010), the landfill in Singapore, with a volume equivalent to 25,200 Olympic-size swimming pools, will be full in 30 to 40 years. With consideration of the lack of landfills and increasing disposal costs, waste management should play a significant role to reduce the demand for landfills. However, as indicated, the benefit is not much recognized by the industry players and thus may not properly contribute to reduction of landfill. It may be required to promote the specific benefit to effectively reduce the landfills in Singapore and to avoid “Crisis of landfill space” in 30 to 40 years.

**Project characteristics vs perception on benefits of waste management**

The survey results identifying if different project characteristics affect benefits of waste management are highlighted in this section. Among the project characteristics elaborated in the Background section, three characteristics namely, project size (less than \$5 million, \$5 to \$15 million, \$15 to \$50 million, or greater than \$50 million), project type (new construction, renovation, or demolition) and key material used (concrete, or steel) were considered by all respondents as “having impacts on the benefits of waste management”, as shown in Table III.

Six respondents did not believe that project nature (residential, commercial, infrastructure, or institutional) could be a project characteristic that may affect the benefits of waste management. One possible reason for the disagreement is that these respondents might not see waste management implemented in all different nature of projects. Furthermore, they may agree that waste management should be applied regardless of the project nature and its benefits would not differ by purposes and/or functions of facilities.

Table IV summarizes respondents’ views on benefits of waste management by breakouts of the project size, project type and key material used. When the project size was categorized into the four groups, depending on the total project cost, all respondents reported that it would be most beneficial to implement waste management to projects costing greater than \$50 million. Observing the results of the other categories, this may imply that efficiency of waste management can be maximized when it is applied to relatively bigger projects. This might be due to the characteristics of small projects. Small sized projects in terms of total project cost may fall into the categories of maintenance and renovation rather than new construction. These projects tend to have smaller size of project teams and their schedules are also fast tracked in general to minimize the impact on the ongoing production of the facilities. Therefore,

Project characteristics	No. of respondents (total = 66)	
	Yes	No
Project size	66	0
Project nature	60	6
Project type	66	0
Project duration	64	2
Key materials used in project	66	0

**Table III.**  
Perception of benefits of waste management by project characteristics

investment or thorough consideration on waste management may not be easily initiated and implemented.

Considering project type, 39.4 per cent of the respondents agreed that demolition projects draw more benefits from waste management. The possible reason for the survey result can be the perception that demolition projects generate more waste when compared to new construction. According to Napier (2008) building related waste is about 164,000 million tons annually, and 9 per cent of the waste is generated from new construction projects, 38 per cent from renovation projects, and 53 per cent from demolition projects. This infers that with intensive implementation of waste management into demolition projects more wastes can be reused and recycled, ultimately appreciating more economical and environmental benefits from waste management. This is also supported by the research documented by Howard Humphries and Partners (1994) who reported the status of the recycling of demolition and construction wastes in the UK.

Exploring which key material used in construction projects affects benefits of waste management, almost 88 per cent of the respondents chose steel. The result might be due to the fact that steel can be recycled repeatedly without any degradation in terms of properties or performance in quality. According to Building and Construction Authority (BCA) (2007), steel construction has excellent low waste credentials during building life cycle and generates very little waste while concrete used for construction projects has limited uses only.

As the last question of the survey, respondents were asked for their advice and suggestion on other project characteristics that are not included in this research and that might have impacts on benefits of waste management. The responses could be summarized as four major categories:

- (1) Contractual arrangement.
- (2) Level of sub-contracting.
- (3) Types of clients.
- (4) Procurement methods.

It is also noted, that the new project characteristics as mentioned previously were provided by respondents such as contractors, clerk of works and project managers rather than site supervisors and quantity surveyors. This could be mostly due to

Project characteristics	No. of respondents (total = 66)	(%)
Project size (million)	< 5	0
	\$5-\$15	0
	\$15-\$50	0
	>	66
Project type	New construction	22
	Renovation	18
	Demolition	26
Key material used in project	Steel	58
	Concrete	8

**Table IV.**  
Perception of benefits of  
waste management by  
project size, project type  
and key material



different involvements in construction projects and different understanding of additional project characteristics that will have effects on the benefits of waste management.

#### *Limitations of study*

There is a consensus among the respondents that different project characteristics may have impacts on benefits of waste management. The difficulty lies in gauging the extent of impact. This study was also limited to views and perceptions of respondents from the Singapore construction industry due to inability to collect quantitative data from construction projects for analyses. As such, the findings of this study may not represent views of the entire construction industry.

#### **Conclusion and recommendations**

The objectives of this research study were:

- to explore the major benefits of waste management; and
- to evaluate the impact of project characteristics on benefits of waste management.

The first part of this study identified different characteristics of projects and major benefits of waste management. As a result, five different characteristics of project and seven benefits of waste management were highlighted. The second part of the research focused on impacts of project characteristics on benefits of waste management and established that different characteristics affect waste management benefits differently even though it is very hard to gauge and justify the extent with definite values. Furthermore, there is no definite characteristic that has the most impact on the benefits. It varies from case to case. However, it is of value to recognize that key materials used for construction projects and types of projects should be considered when implementing waste management. This can be the first step to maximize the benefits from waste management.

As recommendations for future study, characteristics of a project that were not discussed in this study such as contractual arrangements, level of sub-contracted work, procurement methods and clients' requirements can be look into in future. Comprehensive studies on how each characteristic of a project can affect other benefits are not covered in this study. It is also recommended that useful methods and tools to quantify actual benefits from waste management should be explored.

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A - Background information

1. Designation of Respondent:
2. Years of Experience in the Construction Industry:
3. Are you familiar with waste management plan?
  - Very familiar
  - More familiar
  - Familiar
  - Less familiar
  - Not familiar

B - Questions

1. Does your company implement waste management?
  - Yes
  - No
2. What do you think is the most important benefit of implementing waste management?
  - Cost Saving
  - Reduced Demand for Landfill Spaces
  - Improved Resource Management
  - Profit Maximization
  - Quality Improvement
  - Image Improvement
  - Productivity Improvement
3. Do you think that different project characteristics (named below) will affect on benefits of waste management plan?
  - a. Project Size (in terms of total project cost)
    - Yes
    - No
  - b. Project Nature (Residential, Commercial, Infrastructure or Institutional)
    - Yes
    - No

Figure A1.  
Questionnaire

(Continued)

- c. Project Type (Construction, Renovation or Demolition)
- Yes
- No
- d. Project Duration (Time)
- Yes
- No
- e. Key Materials used in Project (Concrete or Steel)
- Yes
- No
4. Do you think as project size increases, it will result in more potential benefits of waste management? (If No, go to Q8)
- Yes
- No
5. Which category do you think will achieve more benefits of waste management?

Category	Project Size
1	\$5 million and below
2	\$5 to \$15 million
3	\$15 to \$50 million
4	\$50 million and above

- Category 1
- Category 2
- Category 3
- Category 4
6. Do you think different types of project will affect the potential/magnitude of benefits from waste management? (If No, go to Q8)
- Yes
- No

(Continued)

Figure A1.

7. Which type of project do you think will result in more benefits?
  - New Construction
  - Renovation
  - Demolition
8. Do you think that benefits of waste management will increase or decrease due to the key material used in construction project? (If No, go to Q10)
  - Yes
  - No
9. Which key material used in a construction project do you think will achieve more benefits?
  - Steel
  - Concrete
10. Is/Are there any characteristic/s that you think may have impact on benefits of waste management?

Figure A1.

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