APPROACHES FOR CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT IN HONG KONG

By

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A THESIS PRESENTED TO THE GRADUATE SCHOOL
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To My Parents

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This research is aiming at providing an overview of the current situations of construction and demolition waste management practice in Hong Kong and formulating strategies on waste minimization. The proposed thesis would provide useful and constructive information for the local and foreign construction companies and help them to achieve better planning and organizing in the waste management process in order to achieve sustainable development.

The research has found out which kinds of waste were commonly reused or recycled and the views of industrial participants towards different waste management strategies, while the limitations in reusing or recycling the waste of various categories were discovered by interviewing. Strategies which had already been adopted by the leading construction companies in Hong Kong have been discussed in the case study.

This research has also provided recommendations to different parties involved in the construction projects, including the government, developers, designers and contractors.

CHAPTER 1
INTRODUCTION

Background of the Research

Hong Kong has become an international metropolis from a small fishing port in just several decades. Now, Hong Kong is one of the most densely populated cities in the world with an overall density of approximately 6,300 people per square kilometer. The city's population increased sharply since the late 1980s, and reaching 7 million in 2007.The population in Hong Kong, however, is continuing to grow due to the influx of annual 45,000 immigrants from the mainland China. In order to cope with this huge population, redevelopment of old urban districts is imperative and inevitable.

Due to the rapid redevelopment programs throughout the past decades, vast amount of construction and demolition waste is being generated every year because of poor waste material control on the construction or demolition sites. The problem of construction and demolition wastage is not only an isolated issue on construction sites, but it also caused environmental problems.

In 2006, Hong Kong generated approximately 17,000 tons of solid waste each day, which is up 30% from 10 years ago. Hong Kong is mainly relying on sanitary landfills and reclamation site for solid waste disposal. This seems to be a cost effective method in short term, but it is not efficacious for long team since land is very scarce and precious in Hong Kong (Mill et al. 1999).

Construction and demolition waste accounted for 27% of all solid waste disposed of at landfills in 2006 (EDP 2007). Despite the fact that reusing, recycling and reducing waste have been encouraged by the Hong Kong government, disposal in landfills is still the most common method used in the construction industry for the disposal of

construction and demolition waste (Hao et al. 2008). Hong Kong is running out of landfill sites for disposal of construction and demolition waste. Thus, construction and demolition waste control is imperious to the sustainable development of the city. Indeed, many materials from construction and demolition can be reused, conserved, and recycled. The amount of waste required to be disposed would be greatly reduced if there is a better construction and demolition waste management system on construction sites.

Objectives of the Research

The proposed thesis is aiming at providing an overview of the current situations of construction and demolition waste management practice in Hong Kong and formulating innovative strategies on construction and demolition waste minimization. The proposed thesis would provide useful and constructive information for the local and foreign construction companies and help them to achieve better planning and organizing in the waste management process in order to achieve sustainable development.

Structure of the Research

This research provides an overview of the current situation of the construction and demolition waste management in Hong Kong by gathering information and opinions from the construction industry. Recommendations and comments on formulating new strategies in waste management are then provided. This research also discusses the constraints and incentives in implementing the new strategies.

Chapter 2 provides an overview of the current situations and practice on construction waste management in Hong Kong. It also provides a summary of the Hong Kong statutory requirements on construction waste management in different scale of

construction projects and the strategies in waste management which have been adopted by other countries.

Chapter 3 describes the methodology adopted in the research.

Chapter 4 summaries the results of the research. It includes the constraints in implementing waste reduction strategies and the views of the industry participants towards the strategies which could be adopted in Hong Kong. It also describes the good strategies which had already been adopted by some of the leading construction companies in Hong Kong.

Chapter 5 discusses the strategies which are applicable in Hong Kong and provides recommendations on implementing such strategies.

Chapter 6 provides a conclusion of the research.

CHAPTER 2
LITERATURE REVIEW

Definitions

The following are the definitions of the key words used in this research.

- CONSTRUCTION AND DEMOLITION WASTE. Waste arising from any land excavation or formation, civil or building construction, roadwork, building renovation or demolition activities. It includes various types of building waste, rubble, earth, concrete, timber and mixed site clearance materials (EPD 2007, p.7).

- LAND RECLAMATION. Land reclamation involves modifying wetlands or waterways to convert them into usable land, usually for the purpose of development (Smith 2009).

- RECYCLING. Recycling includes collecting recyclable materials that would otherwise be considered waste, sorting and processing recyclables into raw materials such as fibers, manufacturing raw materials into new products, and purchasing recycled products (USEPA 2009).

- REUSE. Reuse involves putting an item to another use after its original function has been fulfilled. The products are used a number of times before they are discarded (GRC 2004).

Classification of Construction and Demolition Waste

Construction and demolition waste are normally sorted into two main portions: 1) inert; 2) non-inert (Johnston and Mincks 1995).

1) Inert waste includes rocks, rubble, concrete, cement, asphalt, rubbles, bricks, tiles, stones, soil, sand and asphalt. This kind of waste is suitable for land reclamation. Some of this kind of waste can also be used in recycling.

2) Non-inert waste is around 20% of the total construction and demolition waste (GovHK N.D). It includes wood, timber, paper, metal, bamboo, trees, glass, plastics, junk, organism and fixtures. This kind of waste is not suitable for land reclamation (EPD 2009a), since it will decompose slowly underground by bacterial actions and sink gradually. Such land reclamation projects are commonly aiming at creating new land for

buildings or other structures. If the building structures were built on top of the land with substantial non-insert materials, it would cause seriously structural problems.

Reasons for Minimizing Construction and Demolition Waste

The construction industry consumes large quantities of natural resources and generates a huge amount of construction and demolition waste. This problem is not an isolated issue in construction industries (Cheung et al. 1993). Hong Kong is one of the most densely populated cities among the world and filled with many high-rise residential and commercial buildings. Construction and demolition (C&D) wastes are bulky in size and use up a huge amount of space if they are disposed of at landfills (Poon et al. 2003). Although the rate of construction and demolition waste received at landfills per capita per day in Hong Kong is relatively low when compared with other regions (refer to Table 2-1), it is imperative to reduce the amount of wastes to be disposed at the landfills. The land supply for landfills and building sites is very scarce. Most of the land in Hong Kong is undulating and not suitable for landfills and buildings. Approximately 27% of the public landfill capacity in Hong Kong was used for handling with the construction and demolition waste in 2006 (refer to Figure 2-1) (EPD 2007). If this problem continues, the landfills in Hong Kong will be filled up in 5 to 9 years (Poon 2007). Reducing and recycling construction wastes are therefore a key element of sustainability in future development.

The building industry consumes a considerable amount of resources. Those resources include valuable natural assets like timber and metal. Indeed, There is a large portion of the materials being wasted because of poor material control on building sites (Poon et al. 2003).If the life cycle of the material, from extraction from the nature to its end fate, is closely examined, many resources can be conserved.

Table 2-1. The construction and demolition waste received at landfills in different regions

CITY	C&D WASTE RECEIVED ANNUALLY (tons)	POPULATION	YEAR	PER CAPITA PER DAY (KG)
New York	9,000,000	18,756,000	1998	1.19
Chicago	1,484,610	2,853,000	2007	1.29
Singapore	922,000	4,990,000	2001	0.46
Hong Kong	1,505,625	6,800,000	2006	0.55

Composition of the Construction and Demolition Waste in Hong Kong

The composition of construction and demolition waste is variable. It depends on the types of construction activities taken (Li 2002). The breakdown of the volume of construction and demolition waste received in the public landfills and filling areas are shown in following figures (refers to Figure 2-2 to 2-4).

From Figure 2-2, it was found that over 85% of construction and demolition waste came from renovations and construction works (Li 2002). The renovation works are ususally conducted by small contractors employed by individual households. This kind of waste is difficult to be sorted, since the waste is usually broken into very fine pieces and mixed together. This reduces the possibility of recycling or reusing this kind of waste. Thus, the waste is inevitably disposed to the landfills.

Figure 2-3 shows that near 80% of construction and demolition waste came from private projects. This suggests that private residential and commercial projects are dominant in the construction industry. From Figure 2-4, it shows that concrete was the most commonly found construction and demolition waste among all other categories. This is because most of the buildings in Hong Kong are commonly made up of reinforced concrete in both building structures and envelopes.

Causes of Construction and Demolition Waste during Construction Phase

Summarizing the results from different researchers, the causes of construction and demolition waste generated during the construction phase are listed as following:

- Design changes and design errors would result in dismantling of the work which have already installed. (Faniran and Caban 1998)
- There is a lack of standard guidance for setting up proper waste management procedures on site (Shen et al. 2004).
- There is a lack of contractors' initiatives for engaging proper waste management procedures (Shen et al. 2004).
- Since concrete is the main material used in building the structures and envelopes, extensive use of formwork is required. However, timber formwork usually can be used for one to two times only. Timber formwork comprises 30% of all waste during the construction phase, excluding the site formation and demolition works (Poon et al. 2003).
- Three to five percents of the material was wasted due to excessive material ordering during the construction phase, excluding the site formation and demolition works (Poon et al. 2003).
- Works have to be redone due to poor concrete placement quality and poor workmanship (Poon et al. 2003)
- Wet trades include brick/block walling, plastering, floor screeds, internal and external finishing. The wet trades of finishing work such as screeding, plastering and tiling were identified as the second major waste. It counts for 20% of all waste during the construction phase, excluding the site formation and demolition works (Poon et al. 2003).
- Loss during loading and unloading, damaged bricks due to over-stacking in the storage area and poor products of layering were the possible causes of wastes (Poon et al. 2003).

Waste Minimization Strategies

Generally, the strategies of waste management includes the following (Kibert and Chini 2000):

- Avoid
- Reuse

- Recycle
- Compost
- Burn
- Dispose at landfills

However, composting construction and demolition waste would require extensive use of land. Since the land supply in Hong Kong is too scarce, it is not feasible in Hong Kong. Burning waste would induce the emission of toxic gases and many kinds of construction and demolition waste are not flammable. Thus, this research would focus on the remaining three ways for minimization of construction and demolition waste. They are: 1) avoiding waste; 2) re-using materials; and 3) recycling waste.

Avoiding waste refers to any practice that avoids or minimizes waste at source. Re-using and recycling waste refers to the re-using and recycling of waste materials, and thus, reducing the volume of waste needed to be disposed to the landfills (Ferguson et al. 1995).

It is recommended that minimization of waste at source should be given the highest priority (Crittenden and Kolaczkowski 1995), because it is always more efficient to minimize the generation of waste at source than to develop ways for treating or handling the waste.

Although Re-using and recycling allow waste materials to be put into a beneficial use, reusing and recycling do not completely avoid the waste generation (Faniran and Caban 1998). Reusing and recycling can only reduce the quantity of waste to be eventually disposed to the landfill sites. Since reusing requires less energy and processes in dealing with the waste than recycling, reusing should be put in higher hierarchy than recycling (Crittenden and Kolaczkowski 1995). The hierarchy of the three means of minimization of construction and demolition waste should be: 1) avoiding

waste; 2) reusing waste; 3) recycling waste; 4) disposing waste. Figure 2-5 shows the priority of the options for waste minimizing.

Many studies have found that technology, work process and practice have a huge contribution in generating C&D waste. However, human behavior also has an important role in waste causation and minimization in construction industry (Teo and Loosemore 2001). Thus, apart from improving the current practices and technologies, effective education of the workforce, comprehensive audit procedures and legislations could result in improvement in waste minimization performance (Dainty and Brooke 2004).

Government Incentives for Construction and Demolition Waste Management in Hong Kong

Construction Waste Disposal Charging Scheme

The Hong Kong government introduced the Construction Waste Disposal Charging Scheme in December 2005. The scheme is a waste reduction measure based on the polluter pays principle (EPD 2007). The Polluter pays principle is now used in international environmental law. It refers that the polluting parties are made liable to pay for the damages they cause to the natural environment. The objective of this principle is to shift the responsibility of processing or dealing the C&D waste from governments to the parties who produces such waste (Verma N.D.). This charging scheme is not only intended to provide an economic incentive for contractors and developers to reduce waste but also to encourage reuse and recycling of waste material thereby slowing down the depletion of limited landfill and public filling capacities (Hao et al. 2008).

The scheme mainly comprises the following features (EPD 2007):

- To accept various types of construction waste at different charge rates as Table 2-2

- To mandate the waste producers, i.e. construction contractors, to open billing account with the government for the construction works and pay the waste disposal charges

Table 2-2. Charges for different construction waste under the Construction Waste Disposal Charging Scheme (Source: EDP 2007)

Designated Waste Disposal Facilities	Type of construction waste accepted	Charge per tone
Landfills	Containing not more than 50% by weight of inert construction waste	HK$125
Sorting facilities	Containing more than 50% by weight of inert construction waste	HK$100
Public fill reception facilities	Consisting entirely of inert construction waste	HK$27
Outlying Islands Transfer Facilities	Containing any percentage of inert construction waste	HK$125

*Notes: The exchange rate of HK$ to US$ approximately equals at 7.80 to 1

Effectiveness of the Construction Waste Disposal Charging Scheme

There was about 60% waste reduction in landfills, about 23% in public fills, and about 65% in total waste between 2005 and 2006 (Hao et al. 2008). Table 2-3 shows the daily C&D waste disposal at landfills and public filling areas in 2005 and 2006 and Figure 2-6 shows the trend of total waste sent to landfills and public fills from 1991 to 2006. The annual C&D waste disposal has dropped from 21,450,000 tones in 2005 to 8,561,200 tones in 2006 after the implementation of the Construction Waste Disposal Charging Scheme (refer to Figure 2-6). These data proved that the implementation of the Construction Waste Disposal Charging Scheme has been launched very successfully.

Table 2-3. The daily C&D waste disposal at landfills and public filling areas in 2005 and 2006. (Source: Hao et al. 2008)

	Landfills (metric tonnes per day)	Public fills (metric tonnes per day)	Total C&D waste (metric tonnes per day)
2005	6556 (11%)	52 211 (89%)	58 767
2006	5017 (21%)	18 438 (79%)	23 455

Performance Assessment Scoring System (PASS)

In Hong Kong, near half of the residential projects are developed by the Housing Authority. Thus, the government is the biggest residential developer in Hong Kong. In 2000, the Housing Authority established the PASS assessment system to evaluate the performance of the contractors undertaking the public residential construction works and the quality of work done by the contractors. The results of the assessment would be used as a basis in selecting contractors in future procurement (HKHA 2009).

The assessment system comprises the following areas:

- Works Assessment, including
    - Structural Works Assessment
    - Architectural Works Assessment
- General Assessment, including
    - Management Input Assessment
    - Program and Progress Assessment
- Environmental and Other Obligations Assessment
- Safety Assessment
- Architectural Works (Final) Assessment
- Maintenance Period Assessment

Under the Environmental and Other Obligations Assessment, it requires the contractors to submit a waste management plan to the Housing Department, take up the waste management responsibilities, dispose and monitor construction waste. It also encourages the contractors to sort and segregate construction and demolition waste generated in their construction site for reuse and recycling. This PASS system is still only used in public residential projects.

Environmental Management Plan

The Hong Kong Government introduced a new requirement in December 2005 requiring contractors of all public works contracts to prepare and implement an Environmental Management Plan (EMP). Arrangement for and conducting on-site

sorting of construction waste are mandatory under the relevant contractual provisions and payment items (EPD 2007). These efforts also contributed to the reduction of construction waste disposed of at the waste disposal facilities.

Existing Facilities for Construction and Demolition Waste in Hong Kong

Landfills

Mixed construction waste containing not more than 50% by weight of inert construction waste can be disposed of at the landfills (EDP 2009).

Public Fill Reception Facilities

Public fill reception facilities comprise public filling areas, filling barging points, fill stockpiling areas, fill banks and C&D material recycling facility (EPD 2009b). Such facilities are set up for development projects which accept public fills for reclamation purpose.

In order to reduce the loading in the public landfill, the Hong Kong government has launched several land reclamation programs which utilize a large quantity of fill material (Poon 1997). The current policy specifies that insert materials (e.g. rock, rubbles, bricks, stones, concrete, sand and so on) not larger than 250mm in size and free from decomposable contaminants are acceptable in the public fill reception facilities.

Sorting Facilities

Construction waste containing more than 50% by weight of mixed inert waste can be delivered to the sorting facilities. This helps the contractors, especially for those undertaking small-scale works and not having enough space and resources, to carry out on-site sorting (EPD 2009b). Simple plants consisted of horizontal impact crushers with magnetic separators and static grizzly screens were set up in those sorting sites. The layout of such sorting sites is shown in Figure 2-7.

Outlying Islands Transfer Facilities

Waste contains any percentage of inert materials can be sent to the outlying islands transfer facilities. Those facilities are to provide marine access for refuse transfer vessels to transfer the waste out of Hong Kong (see figure 2.8).

Table 2-4. The amount of waste received in different facilities in 2006 (Source: EPD 2007)

Facilities	Average daily waste intake (tpd)
Outlying Islands Transfer Facilities	205
Landfills	15,039
Public fill reception facilities	25,759

* notes: the data in this table include all kinds of solid waste.

Limitations in Practicing Waste Management in Hong Kong

Contractual Requirements

Some contracts may require the contractors to use virgin materials in construction. For instance, the Government's General Specifications 1992 Edition, specifies to use virgin rock and sand in construction work (Poon,1997). This limits the possibility of using recycled or reused material in construction.

Lack of Willingness for the Public to Accept Second Hand Materials

People may prefer to use new materials or products in their new or newly renovated properties rather than use second hand materials. This causes limited demand for the recycled or recovered products in the market (Poon 2007).

Considerable Time and Cost

The requirements of considerable time and cost in improving environmental performance discourages the owners, developers, contractors and architects to deliver sustainable construction (Shen et al. 1992; Mills et al., 1999).

Little Attention from the Senior Management

Waste management has been receiving less attention from senior management within organizations. More concern is given to the cost for implementing waste management, functionality of the finished products, and whether it is delivered on time and up to the standard (Wong and Yip 2004) than the possible benefits that the organization can gain from the implementation of waste management (Shen and Tam 2002).

Labor Cost

Labor is generally more expensive than the building materials cost. Thus, contractors would rather allow considerable amount of material loss or wastage on site rather than put more human resources in implementing waste management strategies or educating the workers to minimize waste and loss (poon et al 2004).

Use of Heavy Equipment and Plant

The prevalence of small and medium construction enterprises inhibits the industry from investing heavily in the purchase of waste recycling plant and equipment (Wong and Yip 2004).

Successful Strategies of C&D Waste Management Adopted in Other Countries

Australia

In Australia, around 50% to 80% of materials are recovered or reused during the demolition process. The majority of those materials are reused without any form of

reprocessing. In addition, up to 80% of concrete is processed to recover the aggregates for reuse in construction (Crowther 2000).

Mature recycling and recovering industry

There is a well-developed market for reused doors, windows, floorboards, wall lining boards, framing, and the like. Those recovered or recycled materials would be used in residential restoration, renovation and in new housing construction.

Reuse of concrete

70-80% of demolished concrete was recovered for reuse as aggregates. The majority of the concrete was used for in constructing road bases (Crowther 2000). The concrete rubble was transported further to the crushing plant than if it had been transported to a landfill site. The salvaged concrete is broken up by using machinery and the reinforcing bars are removed manually for recycling. In the mid 1990's, crushed concrete could be sold as aggregates for $15 per ton. This provided an effective incentive for the contractors and developers to practice the recycling strategies. Figure 2-9 shows a typical concrete recycle plant used in Australia.

The Netherlands

Legislation and regulations were set to ensure that over 80% of construction and demolition waste is either reused or recycled. The main three legislative policies include Landfill Ban, Provincial Environmental Ordinances, and the Building Materials Decree (Dijk et al. 2000).

Landfill Ban

This policy was launched on April 1st 1997. It prohibits the landfill operators to accept any reusable or burnable construction and demolition waste. All construction and demolition waste must be sent to the sorting plant before delivery to the landfills. The

main objective of this policy is to encourage the construction participants to conduct separation of construction and demolition waste into component streams.

Provincial Environmental Ordinances

The twelve Provinces in the Netherlands regulate the disposal of commercial wastes through the Provincial Environmental Ordinances. These Ordinances require waste collection and processing companies to submit quarterly reports to the Province on the waste volumes which they have received. The Provinces can obtain more information about the composition of the waste and monitor the disposal and processing.

Building Materials Decree

The Decree was introduced to regulate the use of building materials, so as to protect the soil and surface water while ensuring the greatest possibility of reusing the materials. Certain kinds of building materials must not be mixed with the soil on the site. Those materials must be able to be removed when the structure is demolished.

Norway

25% to 50% of the construction and demolition waste is either recycled or reused in recent years. There are several significant private and public initiatives to promote C&D waste minimization (Myhre 2000). The examples of such initiatives are as following:

NORSAS

NORSAS is a government organization which aims at promoting waste reduction and recycling. NORSAS also acts as a national register on all waste handling companies. Those companies have to annually report the volume, types, origins, transport and handling methods of waste to NORSAS.

EcoBuild

EcoBuild is a program financed by both government and private sectors. This program is directed by a board of representatives from the building and real property trade. The aim of this program is to establish a commercial market system for recycling waste, so that the construction and demolition waste would be reduced by more than 70%.

The Norwegian Concrete Association

The Norwegian Concrete Association has developed national guidelines for classification of the use of recycled aggregate in the production of new concrete. This made recycling of concrete become more practical.

USA

USA has adopted LEED standard for many years. LEED provides design and construction guidance for developing green and high efficient buildings. In recent years, the number of certified buildings has almost doubled each year (Kibert 2008). Since the buildings with LEED certifications usually have superior performance in minimizing resource consumption, reducing operating costs and achieving healthy indoor environment, those buildings would achieve higher market values than the conventional buildings.

LEED

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System encourages the adoption of sustainable green building and development practices (USGBC 2008). This rating system awards Platinum, Gold, Silver, or Certified rating based on how successful the buildings have addressed the identified criteria

(Kibert 2009). LEED can be applied to any building types and any life-cycle phases. The key areas of the LEED system are listed as following:

- Sustainable Sites
- Water Efficiency
- Energy & Atmosphere
- Materials & Resources
- Indoor Environmental Quality
- Locations & Linkages
- Awareness & Education
- Innovation in Design
- Regional Priority

Under the category of Materials & Resources, credits would be granted to the selection of sustainably grown, harvested, produced and transported products and materials. It promotes reuse and recycling of construction and demolition waste and encourages the use of recycled products in the building design. It also takes into account the reduction of waste during the construction (USBGC 2008).

Other Strategies Suggested by Other Researchers

Dimensional Standardization

10% of construction waste is generated from the cutting of building materials during the construction process (Poon 2007). The designers should consider dimensions of the building elements to match with the material size standards during the designing phase. Cutting wastes can then be significantly reduced.

Minimizing the Need for Temporary Works

Timber boards used in formwork were the most significant waste type requiring disposal followed by waste derived from wet trades. Waste generation could be significantly reduced by the use of prefabricated elements and metal system formworks. (Poon et al. 2004). Prefabricated concrete elements are usually produced in factories

and are transported to construction sites. By using mass mechanical production, better quality and finishes can be achieved. This could also contribute to cost savings (Poon 2007).

Avoid Late Design Modifications

Late design modifications generally result in demolishing the already built components and redoing of works. Therefore design modifications, if necessary, should be considered early in the design process, and late changes should be avoided. Also, by providing more detailed designs, waste reduction during construction could be achieved by avoiding abortive works and excessive redoing of works (Poon 2007).

Setting Recycling Boxes

Placing boxes for collecting recyclable wastes at proper locations would increase the efficiency of collecting and delivering wastes. The allocation of these boxes can also promote environmental awareness among all working staff on site (Shen et al. 2004).

Waste Sorting-out in Early Stage

The willingness to separate different kind of construction and demolition waste is the key to many waste reduction policies. Unlike other industries, construction and demolition works generate waste on specific schedule (i.e. during different phases of the progress). This makes separation of the waste easier than in other industries, like manufacturing or chemical industries (Johnston and Mincks 1995). Planning for sorting is very important. Planning allows reusable waste materials to be sorted out as soon as they are generated and delivered to designated locations. The sorting-out at the point of waste generation is easier to do than that at later stages (Shen et al. 2004). Such practice can also avoid the increase of waste volume when the project proceeds. Earlier waste sorting-out can avoid the possibility that the usable and recyclable waste

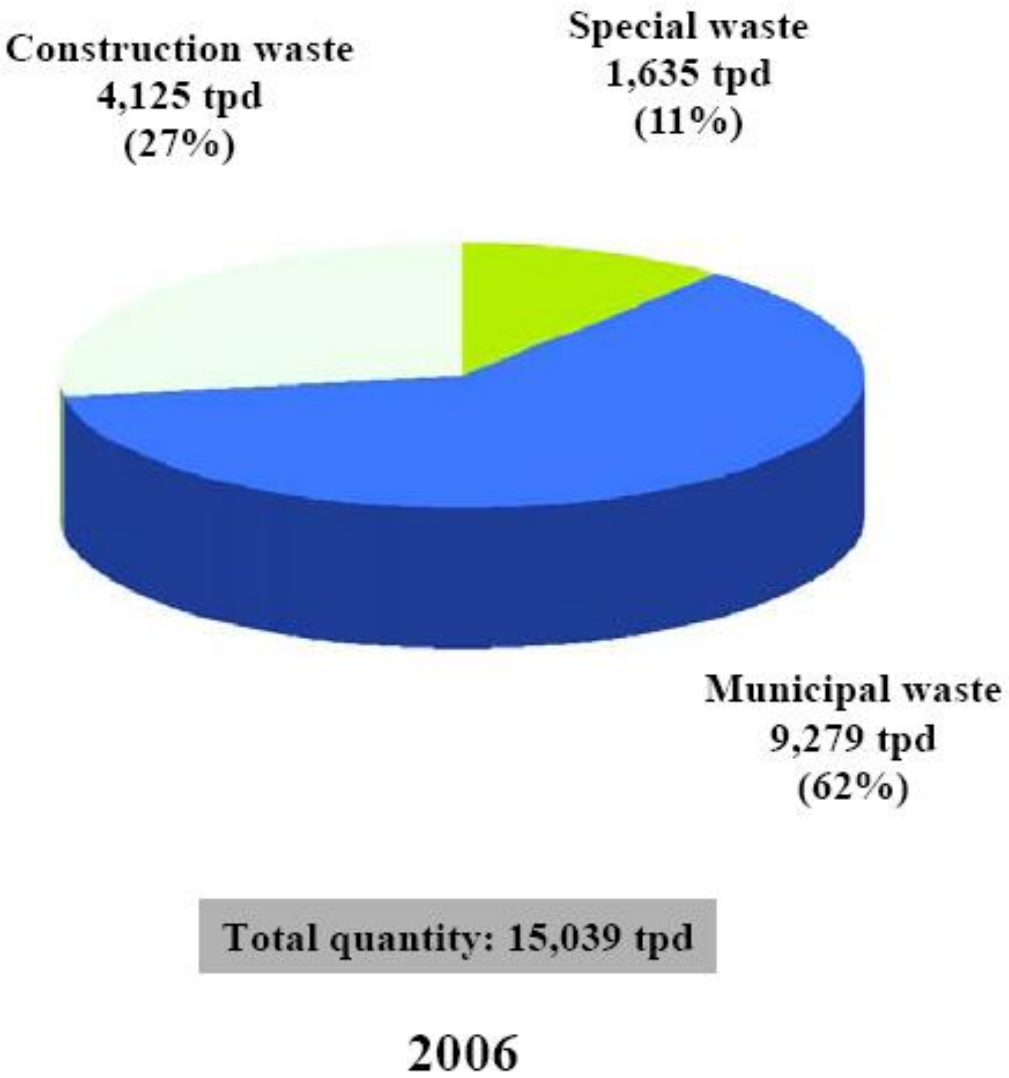
materials are mixed with other debris. For the current practice in Hong Kong, waste sorting is uncommon and only a few kinds of reusable wastes are collected at a project's late stages.

Sub-contractors' Responsibilities

Requiring the sub-contractors to be responsible for purchasing of their materials and disposing of their wastes provides a dual incentive to keep the wastage to minimum. Contractors may also impose a limit on the amount of waste on the sub-contracts. The contracts may include penalty clauses if the amount of waste exceeds the limit and bonus clauses if the subcontractors are able to control the amount waste in a certain level. (poon et al. 2004)

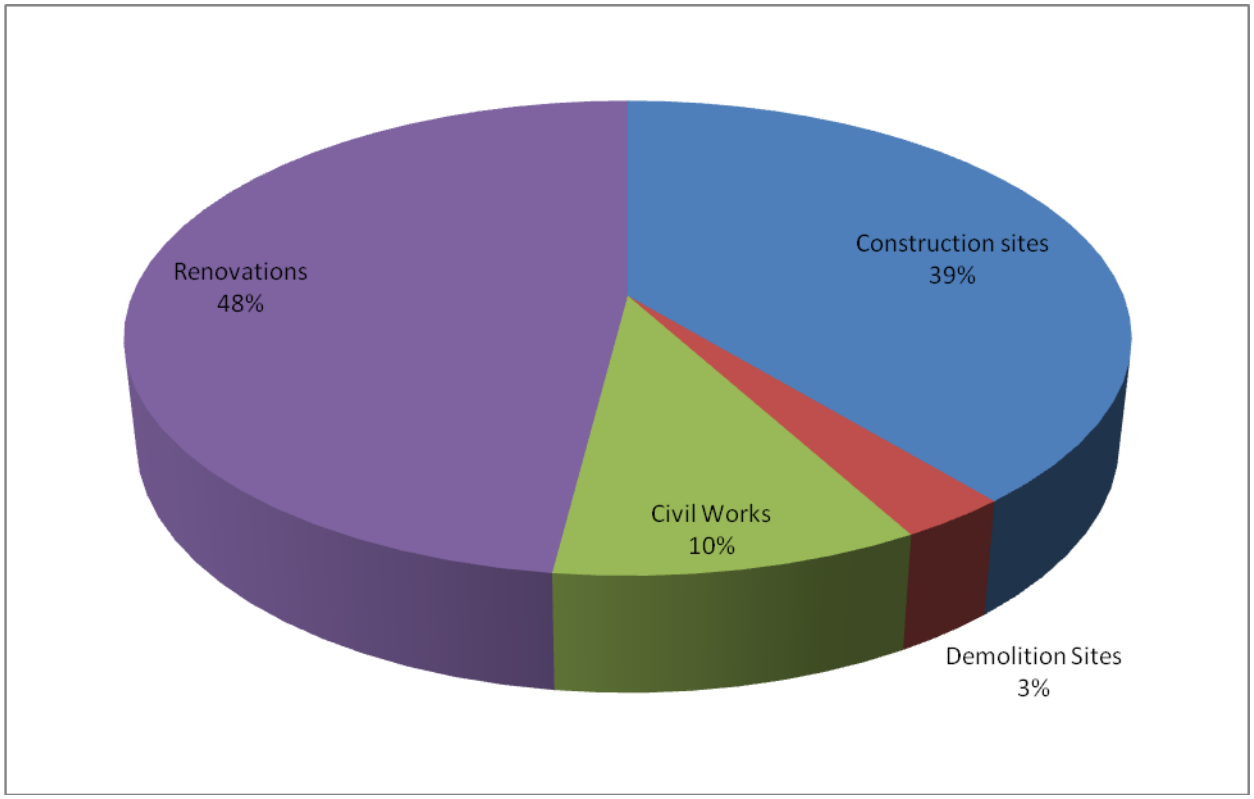
Regular Site Inspection and Review of the WMP Periodically

Site inspection should be carried out on a regular basis. The inspection should include the issue regarding reduction of construction waste and environmental protection. Since different contractors use different self-monitoring system, it is difficult for the Housing Authority or Environmental Protection Department to evaluate their effectiveness. The owners or developers should provide a detailed checklist for the contractors' reference. The contractor should also review the Waste Management Plan periodically to identify the need of amendments (Poon et al. 2004).



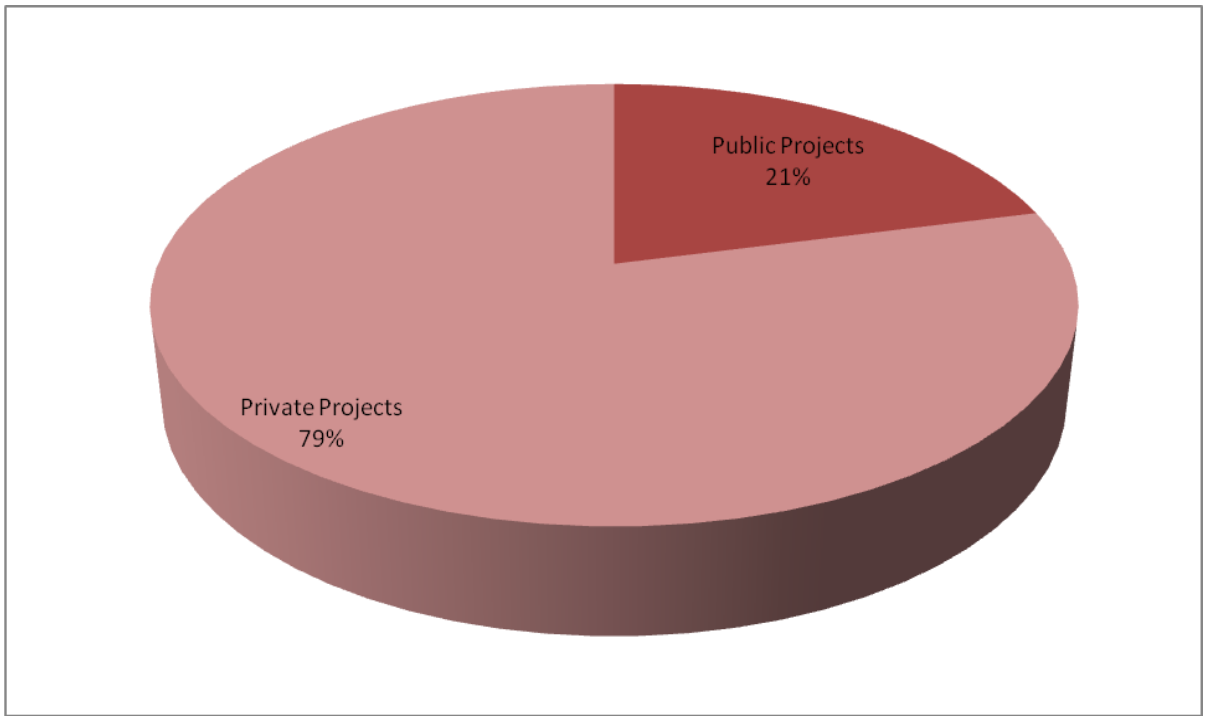
*Notes: Municipal solid waste includes domestic waste, commercial waste and industrial waste. It does not include construction waste and chemical waste. Special waste is the waste that requires special disposal arrangement. That includes animal carcasses, asbestos, chemical waste, clinical waste, condemned goods and etc.

Figure 2-1. A pie-chart showing the composition of solid waste received in landfills in 2006 (source: EPD 2007)



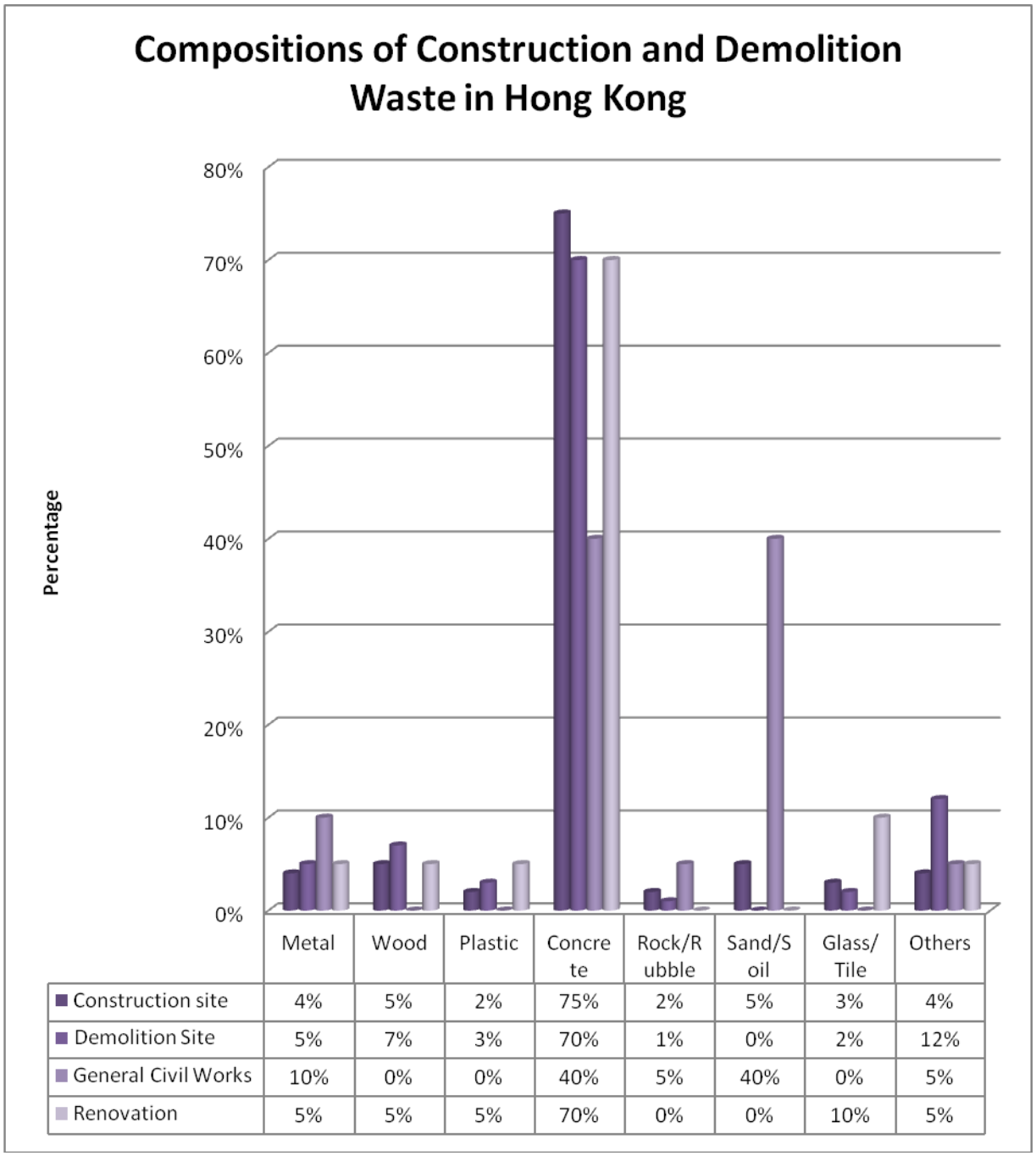
*Notes: The calculation of the percentage of waste is based on volume. The construction works in this set of data also included the waste generated during site formation, dismantling of the existing structures on the construction site and the construction phase.

Figure 2-2. A pie-chart showing the percentage the construction and demolition waste from different kinds of construction and demolition activities (Adopted from: Li 2002)



*Notes: The calculation of the percentage of waste is based on volume.

Figure 2-3. A pie-chart showing the ratio of construction and demolition waste from private projects to public projects (Adopted from: Li 2002)



	Metal	Wood	Plastic	Concrete	Rock/Rubble	Sand/Soil	Glass/Tile	Others
Construction site	4%	5%	2%	75%	2%	5%	3%	4%
Demolition Site	5%	7%	3%	70%	1%	0%	2%	12%
General Civil Works	10%	0%	0%	40%	5%	40%	0%	5%
Renovation	5%	5%	5%	70%	0%	0%	10%	5%

*Notes: The calculation of the percentage of waste is based on volume. The construction works in this set of data also included the waste generated during site formation, dismantling of the existing structures on the construction site and the construction phase.

Figure 2-4. A bar chart showing the composition of construction and demolition waste received in the public landfills and filling areas from different kinds of activities (Adopted from: Li 2002)

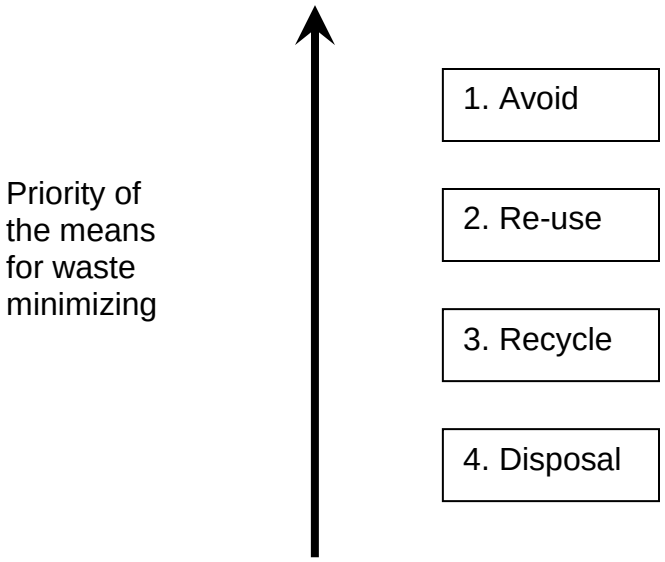


Figure 2-5. Waste management hierarchy (adopted from: Faniran and Caban 1998)

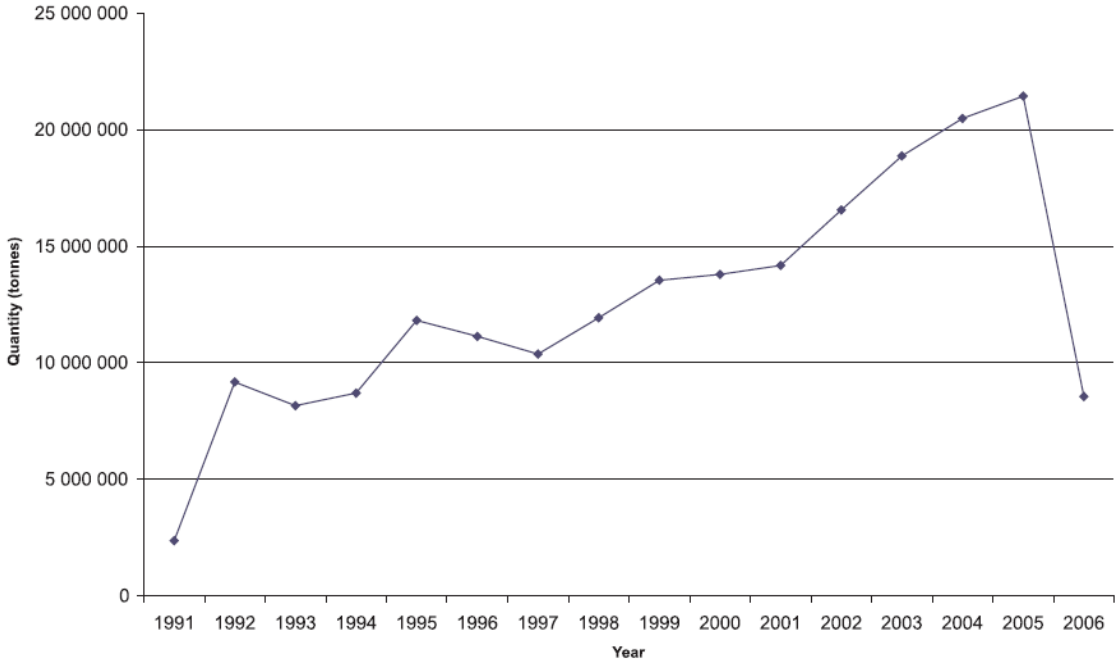


Figure 2-6. A line-chart showing the quantity of C&D waste received in both landfills and public filling area from 1991 to 2006 (Source: Hao et al. 2008)

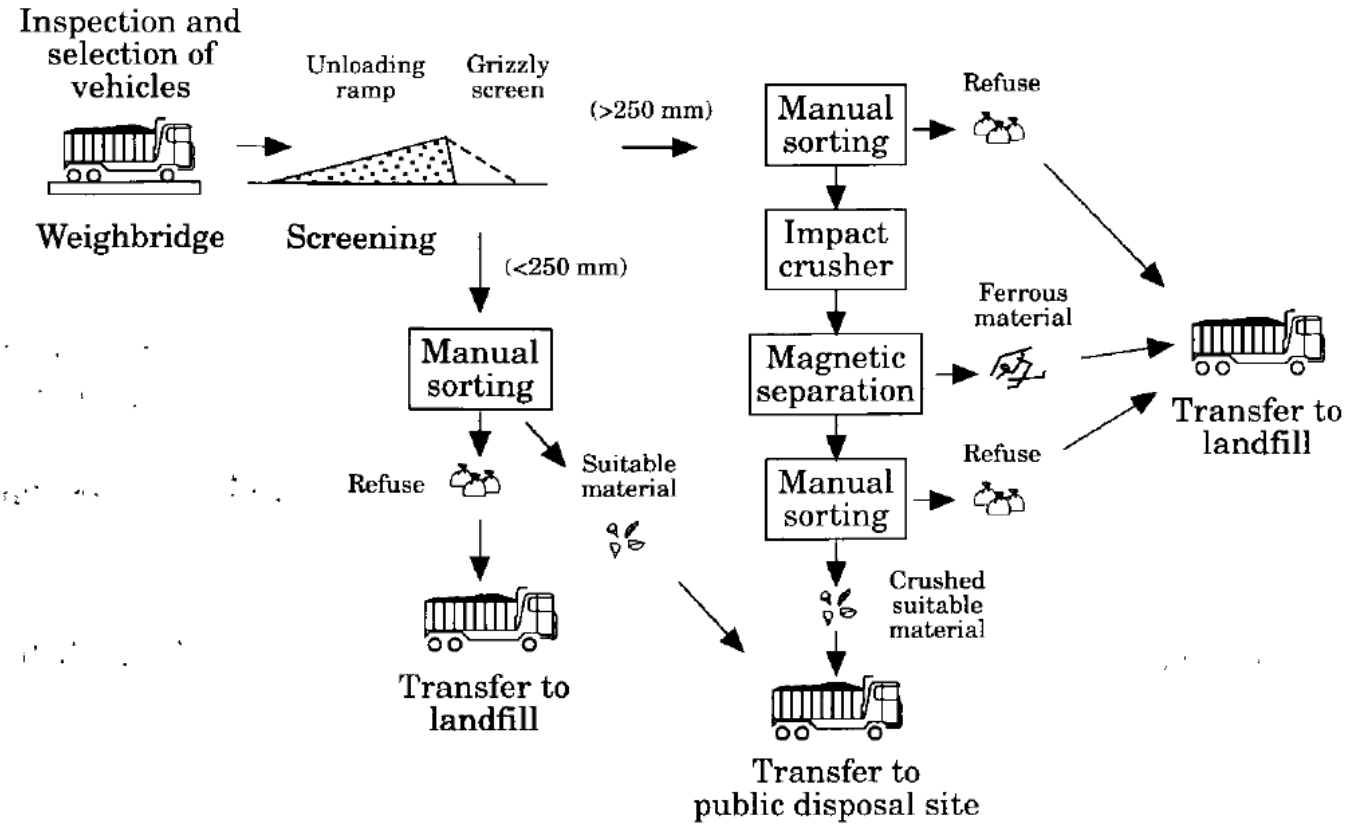


Figure 2-7. A schematic flow diagram of a sorting site (Source: Poon 1997)

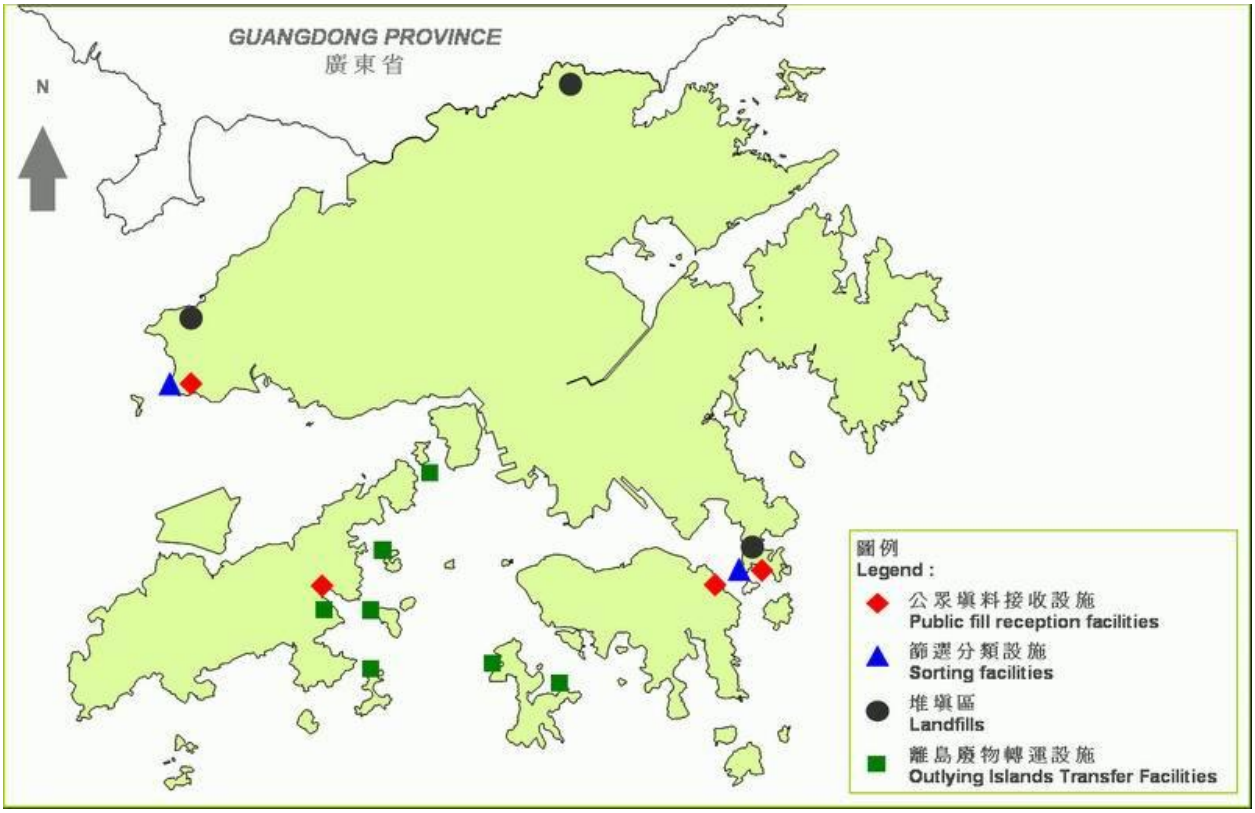


Figure 2-8. A map showing the location of the facilities for construction and demolition waste in Hong Kong (Source: Hong Kong Government N.D.)

Figure 2-9. Concrete recycling plant in Brisbane, Australia (source: Crowther 2000)

CHAPTER 3
METHODOLOGY

This chapter is to describe the methodology used in this research. The steps taken to form a logical flow of the research were as follows:

- A literature search was performed on material related to current practices in Hong Kong and in other counties.
- The data needed for the analysis was identified.
- The sources of data were identified.
- Survey questions were designed to collect the necessary data.
- Identify what kind of information is needed from interviews.
- The results from the survey content from interviews and case studies were administered.
- Assess the limitations of waste management in Hong Kong and potential means for improvement current practices.

Thus, the data of this research came from three sources:

- Surveying the target group by questionnaire
- Interviewing with management staff of selected construction companies in Hong Kong
- Case study

Surveying

The aims of this survey are to find out which kinds of waste are commonly reused or recycled and the views of industrial participants towards different waste management strategies. 352 sets of questionnaire (Appendix 1) were sent via email and fax to the members of the Hong Kong Construction Association and the management teams of construction projects with high demand for construction and demolition waste management during the period of September 15 to 25, 2009. Such construction projects included redevelopment projects, residential housing complexes, civil engineering

projects, and high-rise commercial buildings. The respondents were consultants, engineers, project managers and environmental, health and safety officers for the selected projects. By the date of September 29, 2009, 35 completed questionnaires were received from the respondents. The overall response rate of this survey was 9.94%. The percentage of the types of works being performed by the respondents are shown in Figure 3-1.

The questionnaire comprises seven questions:

Question 1: to find out which kinds of waste materials have been reused

Question 2: to find out the main reasons for not reusing the waste materials

Question 3: to find out which kinds of waste materials have been recycled

Question 4: to find out the main reasons for not recycling the waste materials

Question 5: to find out if the responding companies have a plan designated for construction waste management

Question 6: to find out the views of industrial participants towards different waste management strategies

Question 7: an open question asking for other possible strategies to improve the current situation

Upon receiving the completed questionnaires, the data were inputted into a spreadsheet for further analysis. For Question 1, 3, and 5, descriptive statistics were used to describe the current situation. For Question 2, 4, 6, the respondents were asked to rank the options from 1 to 8 (1 to 9 for Question 6). Rank 1 represents the most possible option while rank 8 (or 9) represents the least possible option. Then a scoring system was applied to the rankings. 8 points (or 9 points for Question 6) would be

assigned to the option with rank 1; 7 points would be given to the option with rank 2, and so on. The scores of each option would be summed up for analysis.

Interviewing

The main purpose was to find out the limitations in reusing or recycling the waste of various categories. Two interviews were conducted on September 30, 2009 and October 1, 2009. One of the interviewees was an environmental engineer while the other on was an environmental, health and safety officer. Each of the interviews lasted for approximately twenty minutes and was conducted on via telephone conversations.

The interview was conducted in Cantonese, since Cantonese is the primary language in Hong Kong. After each interview, contents were summarized into text for further analysis.

Case Study

The purpose of the case study is to investigate the strategies which had already been adopted in dealing with different kinds of waste by the leading construction companies in Hong Kong. The information of the case study is based on a site visit conducted on August 4, 2009 in Hong Kong.

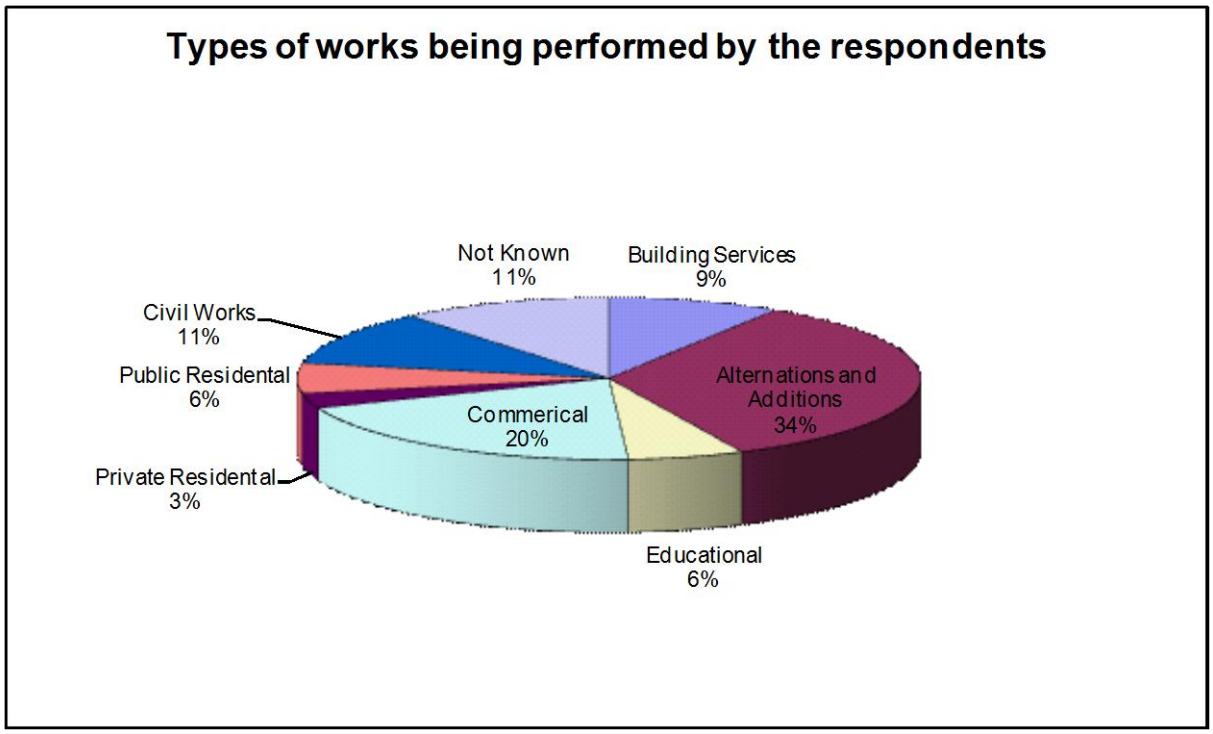


Figure 3-1. A pie chart showing the percentage of the types of work being performed by the respondents

CHAPTER 4
RESULTS

This chapter summarizes the results of the research. The results are based on the survey and follow-up interviews. This chapter outlines the constraints in implementing waste reduction strategies and the views of the industry participants towards the strategies which could be adopted in Hong Kong. It also describes the good strategies which had already been adopted by the leading construction companies in Hong Kong in the case study section.

Reusing

Overview

Figure 4-1 shows the percentage of companies which have reused different kinds of materials and Table 4-1 shows the mean, mode, median and standard deviation of the reuse rate of various waste materials among the companies which have reused the materials.

From Figure 4-1, the responding companies would mainly reuse metal, wood, paper and bamboo. The percentages of companies which have reused those kinds of materials are 74%, 74%, 54% and 60% respectively. The analysis below is based on the data from the survey and the follow-up interviews.

Metal

According to the interviewees, metal price has been appreciated for more than thirty percents during the past decade. The engineer would firstly inspect the condition of the metal. If the metal elements were suitable for the new construction work, those elements would usually be reused. The most common metal elements which had been reused included the following items:

- Metal formworks
- Steel columns
- Steel piles
- Metal Pipes (e.g. cast iron, copper)
- Metal railings
- Metal doors

However, in some cases, the condition of the metal elements might not be suitable in the new construction works. For instance, the metals were rusted due to aging of the elements and the dimensions of the existing materials did not suit the new works.

Concrete

Reusing the existing concrete elements in the new building structures is not common in Hong Kong. The main reason is that the existing elements do not dimensionally match with the new building designs. In addition, due to the aging of the concrete, it may not be able to support the structures and the loading of the new buildings.

Glass and tiles

These kinds of materials were fragile and easily be broken during demolition. In addition, the recovering cost was expensive. Thus, those kinds of materials would usually be disposed rather than be reused.

Wood

The most common wood elements which had been reused included the following items:

- Timber formwork
- Wood floor
- Wood door

Due to the prevalence of in-situ reinforced concrete in buildings, extensive use of formwork is needed. Most of the timber formwork would be used more than one times. However, it depends on the workmanship and the formwork stripping process.

Some high quality wood floor and door would also be recovered and reused.

Rocks, rubbles and sand

These materials could be used in sub-bases of piling structures or ground slabs and backfilling. However, this would require extra labor hours and extensive space for sorting, screening, jack-hammering and storing the aggregates. In most of the cases, it requires engineers to inspect if the rocks, rubbles and sand were free from contaminations for the purpose of using them as backfilling. Some builders would prefer to use imported materials for backfilling, in order to save time.

Wires

Due to aging of the wires, the wires in the existing building may not be safe and suitable to be reused in the new construction work. According to the interviewees, the cost of recovering the wires would not be much cheaper than buying new ones. Thus, most of the builders would prefer to dispose the wires rather than recover them.

Plastics

Most of the builders would reuse the plastic tools, like buckets, during the construction. However, the builder usually would not reuse the plastics from the existing structures, since the cost of virgin materials was low when compared with the cost of recovery.

Toilet cups

Many owners would not accept imported second hand toilet cups in their properties, since they considered such toilet cups were unhygienic. Furthermore, according to the interviewees, the recovery cost of toilet cups was high.

Paper, Cloth and Textile

Paper includes packaging waste, office paper, cardboard and newspaper. Cloth and textile includes carpets, towels, wiping cloth and canvas. Some of these materials might be contaminated during the construction and demolition or be wetted due to exposure to the weather. These materials would not be suitable for reuse in such situations.

Bamboo

Bamboo is widely used as scaffolding in Hong Kong, due to its stiffness, low cost and flexibility. Most of the bamboo would be used more than once. However, bamboo would become brittle as exposed to the weather. It then would not be suitable to be reused again.

Table 4-1. Mean, mode, median and standard deviation of the reuse rate of various waste materials among the companies which have reused the materials

	Metal	Concrete	Glass/ Tiles	Wood	Rock/ Rubble	Wires	Plastic	Sand/ Soil	Toilet Cups	Paper	Cloth/ Textile	Bamboo
Mean	33%	12%	0%	39%	15%	27%	19%	15%	16%	41%	26%	62%
Mode	30%	10%	0%	30%	10%	10%	10%	10%	20%	30%	10%	70%
Median	30%	10%	0%	35%	14%	20%	15%	10%	18%	30%	20%	60%
S.D.	27%	8%	0%	21%	9%	23%	12%	12%	5%	27%	22%	19%

Reasons for Not Reusing the Waste Materials

The mains reasons which made the responding companies not reusing the waste materials are: (see Figure 4-2)

- High recovery cost of the waste materials
- Lack of space for storage

- Lacks of special contractors to recover the waste materials in the market

The scores of the three reasons are 210, 174 and 168 respectively.

High recovery cost

High recovery cost would be the main barrier for the construction companies to reuse the waste materials. The cost of recovery also includes the transportation cost from the site to the companies for refurbishing or recovering of the waste. When the cost of recovery is high or even similar when compared with cost of buying new materials, the construction companies would prefer to use new materials, since the construction companies could save labor efforts, time and space in sorting and storing the reusable materials.

Lack of space for storage

When the reusable materials were dismantled, they might not be installed to the new works until the project is nearly finished. For instance, the electricity wires are dismantled from the old building and it would not be installed until the building structure is completed. The building services works are usually conducted in the late stages of the overall progress. Thus, it requires the construction companies to store the waste materials from the very beginning to the late stage of the project. Since the site areas of the construction projects in Hong Kong are very limited, the builders might not be able to store the materials in such case. Such materials have to be disposed.

Lacks of special contractors in the market

The recovering market is very immature. The builders are always not able to find special contractors to recover the waste materials in the market, even though there are suitable materials for reuse.

Recycling

Overview

The analysis below is based on the data from the survey and the follow-up interviews. Figure 4-3 shows the percentage of companies which have recycled different kinds of materials and Table 4-2 shows the mean, mode, median and standard deviation of the recycle rate of various waste materials among the companies which have recycled the materials.

From Figure 4-2, the responding companies would mainly recycle metal, and paper. The percentages of companies which have recycled such materials are 97% and 74% respectively.

Metal

The recycling value of metal is highest among all other categories of waste. According to the interviewees, steel and iron could be sold at HK$900 to HK$2000 per ton (the linked exchange rate of US$1 to HK$1 is 1:7.8), depending on the condition and purity of the materials. Copper and aluminum are even more valuable. They could be sold at around HK$15000 and HK$8000 per ton respectively. Thus, the recycling rate of metal was the highest among different kinds of materials. The most common metal elements which had been recycled included the following items:

- Aluminum windows frames
- Aluminum or stainless steel sinks
- Metal Pipes (e.g. copper pipes or cast iron)
- Steel columns
- Steel reinforcement bars
- Concrete

The most common ways of reusing concrete were to break the concrete elements into fine pieces and then reuse them as aggregates in sub-bases of piling structures or

ground slabs and backfilling. However, this would require extra labor hours and extensive space for sorting, screening, jack-hammering and storing the aggregates. The small scale construction company would tend not to reuse concrete as they could not afford extra time, cost and machinery in breaking the concrete.

Rocks, rubbles, sand, soils and glass

Those kinds of materials could be recycled as aggregates for road bases, paving blocks and concrete. However, this kind of recycling technology was not well-developed in Hong Kong. Thus, recycling such materials was still not prevalent in Hong Kong.

Wood and bamboo

Wood and bamboo could be recycled into various products, for example, paper, landscaping products, fertilizers, furniture, flooring, and pet littering products and so on. However, the recycling value received by the builders was low. In most of the cases, such recycling value could not even cover the transportation cost from the site to the recycling companies. In addition, waste wood materials were usually bulky in size. This increased the handling cost and transportation cost.

Wires

Wires could be recycled by separating the wrapping plastic and the copper wires. However, this required extensive manpower and the quantity was usually small. So, many construction companies would not consider recycling the wires.

Plastics

Plastic wastes were usually mixed with different plastic materials (e.g. nylon, polystyrene and PVC). It is difficult to identify different kinds of plastic materials simply by visual observations. This would reduce the possibility of recycling the plastic wastes

and the recycling value. Plastic wastes also required extensive space for temporary storage. As a result, most of the plastic wastes are sent to landfills.

Papers

According to the interviewees, papers could be sold at HK$700-1000 per ton. Most of the paper waste would be recycled, except for those which have been contaminated with other substances, like greasy and chemicals.

Table 4-2. Means, modes, medians and standard deviations of the recycle rate of various waste materials among the companies which have recycled the materials

	Metal	Concrete	Glass/ Tiles	Wood	Rock/ Rubble	Wires	Plastic	Sand/ Soil	Toilet Cups	Paper	Cloth/ Textile	Bamboo
Mean	67%	6%	15%	18%	8%	16%	12%	11%	8%	57%	6%	25%
Mode	90%	5%	20%,25%	10%	5%	10%	10%	5%	10%	60%	5%	25%
Median	70%	5%	20%	10%	5%	10%	10%	5%	8%	60%	5%	25%
S.D.	24%	5%	13%	17%	7%	14%	8%	14%	3%	26%	5%	20%

Reasons for Not Recycling the Waste Materials

The mains reasons which made the responding companies not recycling the waste materials are (see Figure 4-4):

- Tight schedule
- Lack of demand in the market
- Lack of space for sorting

The scores of the three reasons are 218, 192 and 190 respectively.

Tight schedule

The land prices in Hong Kong are very expensive. The owners of the construction project would often squeeze the construction time, so that they get the return from their investment (e.g. rental income, profit from selling the properties) and pay back the loans earlier. Therefore, the project schedules are tight. Most of the construction companies were not able to afford extra time and man hours in sorting and storing the recyclable

materials. They would rather allocate budget and resources in the real progress of the projects.

Lack of demand for recyclable materials in the market

The recovering market was very immature. The construction companies were not able to find recycling companies to recover the waste materials in the market, even thought there are suitable materials for recycle.

Lack of space for sorting

Retrieving recyclable materials requires extensive space for sorting. The site areas of the projects in Hong Kong are very limited, due to the high land prices. The construction company might not be able to allocate sorting area for retrieving recyclable materials. Such materials have to be disposed in such cases.

Waste Management Planning

94% of the responding companies did not have a formal plan which is designated for construction and demolition waste management in their construction sites (see Figure 4-5). The current legislations did not mandate the construction companies to have such plans before the commencement of the works. Indeed, such planning is critical to the success of waste management. It specifies the goals of the waste management and the strategies and procedures in dealing with the construction and demolition waste materials. The subcontractors and the foremen could then have a comprehensive guideline to follow.

Opinions Towards Possible Strategies

The responding companies had favorable opinions towards the following options (refer to Figure 4-6):

- Legislations to mandate contractors a minimum percentage of C&D waste reuse and/or recycling in any construction projects.
- Government provides incentives to the contractors or developers with high percentage of C&D waste reuse/recycle (e.g. allows higher gross floor area to site area ratio, lower the tax rates, etc.)
- Government subsidies the C&D waste reuse/recycling industries
- Include a clause in the contract requiring a C&D waste management plan for both private and public projects

The scores of the above four options are 265, 242, 232 and 209 respectively.

Case Study

The purpose of the case study is to investigate the strategies which had already been adopted in dealing with different kinds of waste by the leading construction companies in Hong Kong. This reveals what the industrial participants could do based on current technology and resource constraints.

Company Background

The Company and its subsidiaries are engaged in the business of civil engineering, building construction, alternation and addition works, renovations, fitting-out, building repair and maintenance, property investment, construction management, development and contractor finance. The Company's annual turnover is of approximately HK$1,000 million. It is included in the List of HKSAR Approved General Building Contractors, List of Building Contractors for Housing Authority and List of HKSAR Approved Contractors for Public Works (Group C) of Categories of Buildings, Roads and Drainage, Site Formation and Water Works.

The company has established an environmental management system and was certified to ISO 14001:2004 Environment Management System Standard by Hong Kong

Quality Assurance Agency. It has also attained several awards related to the aspects of environmental protection in recent years.

Contract sum of the project

Approximately HK$ 100 million (the linked exchange rate of US$ to HK$ is 1:7.8)

Project description

The project mainly included the following components:

- One 35-storey non-standard domestic block (Block 3), which is approximately 63m x 45m overall on plan and approximately 98m high from ground floor to main roof level;
- One 41-storey non-standard domestic block (Block 4), which is approximately 47m x 45m overall on plan and approximately 114m high from ground floor to main roof level;
- One 41-storey non-standard domestic block (Block 12), which is approximately 69m x 36m overall on plan and approximately 114m high from ground floor to main roof level;
- One single-storey Integrated Children and Youth Services Centre at the ground floor of Block 3 including construction of footings, piling and pile caps;
- Site formation works including one approximately 130m (length) x 13m (height);
- Site formation works including a series of approximately 104m (length) x 4.2m (height) retaining wall. Significant rock excavation in connection with construction of base slab of the retaining wall and mass concrete fill underneath the base slab of the retaining wall.

Planning for Construction and Demolition Waste Management

The company has established a plan for construction and demolition waste management. The purpose of the plan was to provide details of the means and measures for reducing the environmental impact of the construction waste generated throughout the execution of the work. It also provided a comprehensive guideline for their subcontractors and employees to follow.

The plan included the following items:

- Goals
- Organization structure for waste management
- Types and quantities of wastes would be generated during the execution of the work
- Timing of waste arising
- Procedures of handling different kinds of waste
- Layout plan for on-site waste sorting
- Areas for waste storage
- Monitoring and auditing program

Arrangement for Construction and Demolition Waste Disposal

All construction and demolition (C&D) waste would be sorted to:

- Non-inert portion (Landfills)
- Inert C&D waste(Public Fills)
- Chemical Waste
- Recyclable materials e.g. metal

All C&D materials arising from or in connection with the construction and demolition work would be sorted on-site and be separated into different categories for disposal at landfills, public filling areas, or reuse and recycling as appropriate.

It would be conducted immediately at designated points or at the source on each floor to avoid loss or leakage during handling (Refer to Figure 4-7, 4-8 and 4-9).

Procedures in Sorting Different Kinds of Waste

Foremen of each block would ensure all the C&D materials generated from the buildings was sorted at source as the following procedures:

C&D materials would be separated manually into general C&D waste and inert waste and then stored temporarily at the designated locations on each floor.

Different kinds of C&D materials (i.e. general C&D waste and inert waste etc.) would be placed separately next to the refuse chute at each floor (see Figure 4-10).

To avoid contamination, different kinds of C&D materials would be disposed separately via the refuse chute to the refuse collection point at ground level. The schedule is shown as following (Refer to Figure 4-11).

- For every Monday, Wednesday and Friday: Only inert portion (i.e. concrete, bricks, sand and soil) would be disposed thru the refuse chute to the refuse collection point.
- For every Tuesday, Thursday and Saturday: Only bamboo, plastics, timber and general C&D waste would be disposed thru the refuse chute to the refuse collection point.

The waste collected on the refuse collection point at ground level would be removed promptly so that different kind of wastes would not be mixed together (See Figure 4-12).

Some C&D waste (e.g. pipe-duct), due to its sizes or dimensions, is not suitable for dumping thru the refuse chute. Workers would collect and transfer this special waste manually to the refuse collection points at ground level for collection.

To avoid spillage and contamination, Chemical waste would be collected separately and transferred manually to the designated chemical waste storage facilities on-site. The chemical waste would be collected by the licensed-collector for proper disposal.

Useful materials such as reusable timber, rubble and steel/metal would be separated for reuse. Where it is no longer reusable, steel and metal items will be sent as scrap for recycling. Reusable or recyclable materials would be sorted from the waste manually and stored separately in the designated container to avoid contamination (See Figure 4-13).

Concrete Recycling

The existing old structures of site were several ten-story high buildings which were made up by reinforced concrete. In order to reduce the amount of inert materials sent to the public filling areas and landfills, the company has recycled a large quantity of concrete from demolition.

The concrete was firstly broken by a jack-hammer. The steel bars inside the concrete were picked out manually. The concrete was then piled up in a designated area to ensure it would not be contaminated by other materials (see Figure 4-14).

The broken concrete was mainly used as aggregates in the sub-bases of the piling system (e.g. pile cap and ground beam) and the ground slab. The size of aggregates should not exceed certain dimensions according to the specification. Wire nets were used to screen out the large pieces of concrete (see Figure 4-15).

Through this strategy, over 70% of the concrete from demolition were recycled.

Other Strategies Adopted to Reduce the Amount of Waste to be Disposed

Use of metal falsework and metal formwork

The metal system falsework and metal formwork can be reused more than hundred times. They can also be recycled at the end of the lifecycle. This can reduce the amount of bamboo and timber waste disposed at the landfills and public filling areas (see Figure 4-16, 4-17 and 4-18).

Use of precast elements

Waste generation can be significantly reduced by the use of prefabricated elements. Prefabricated concrete elements were produced in factories and transported to construction sites. By using mass mechanical production, better quality and finishes could be achieved. In this project, massive prefabricated façade system was adopted.

The window frames have already installed inside the prefabricated façade system (see Figure 4-18).

Placing recycling boxes in prominent locations

Placing recycling boxes for collecting recyclable wastes at proper locations would increase the efficiency of collecting and delivering wastes. This could also promote environmental awareness among all working staff on site.

Yellow boxes were used for collecting aluminum materials; Blue boxes were used for collecting paper waste; and brown boxes were used for collecting plastic bottles (see Figure 4-19).

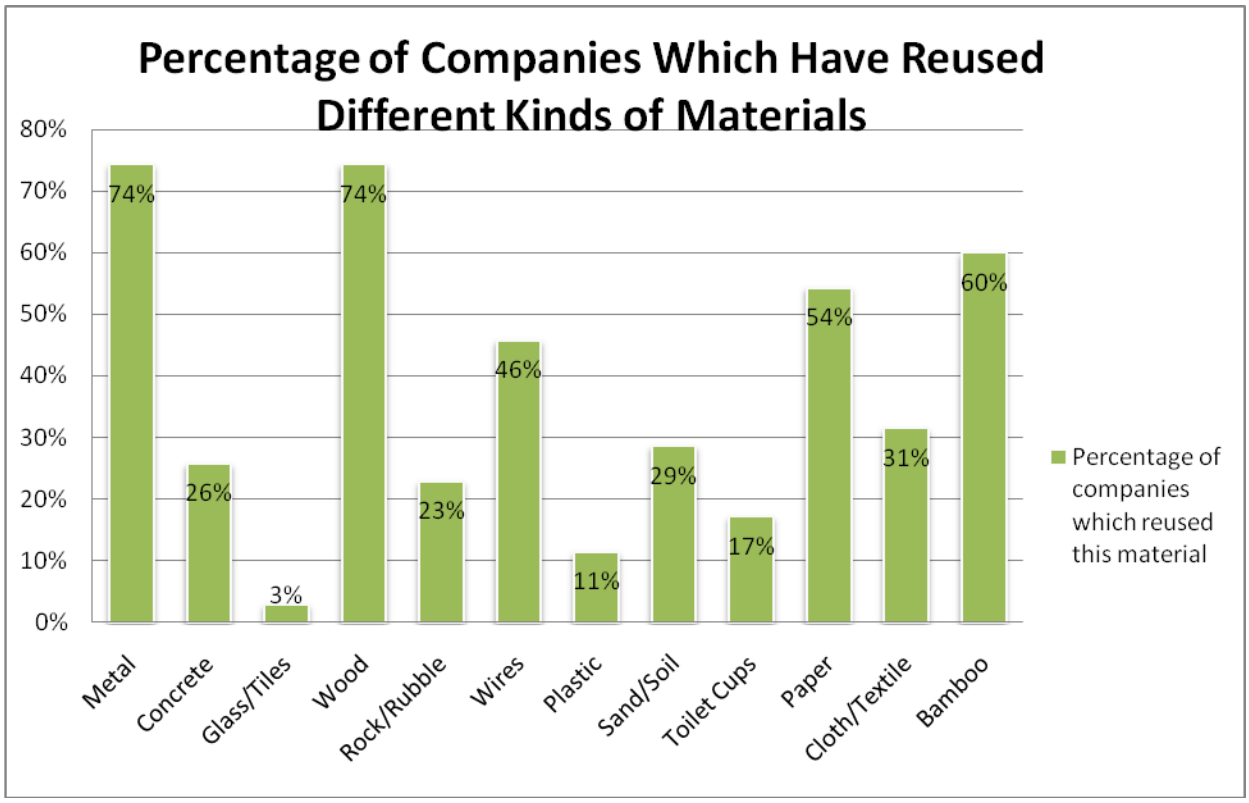


Figure 4-1. A bar chart showing the mean percentage of companies which have reused different kinds of materials

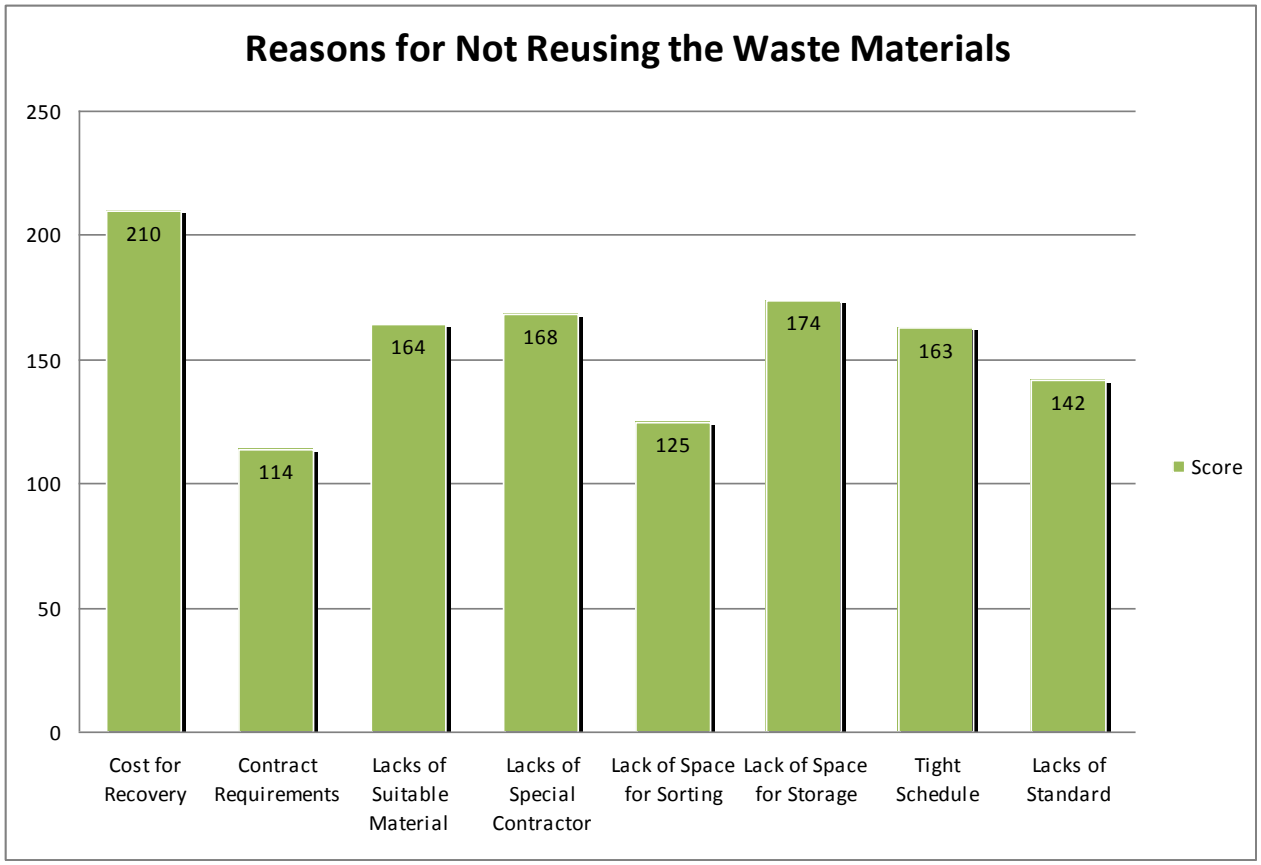


Figure 4-2. A bar chart showing the scores of the reasons for not reusing the waste materials

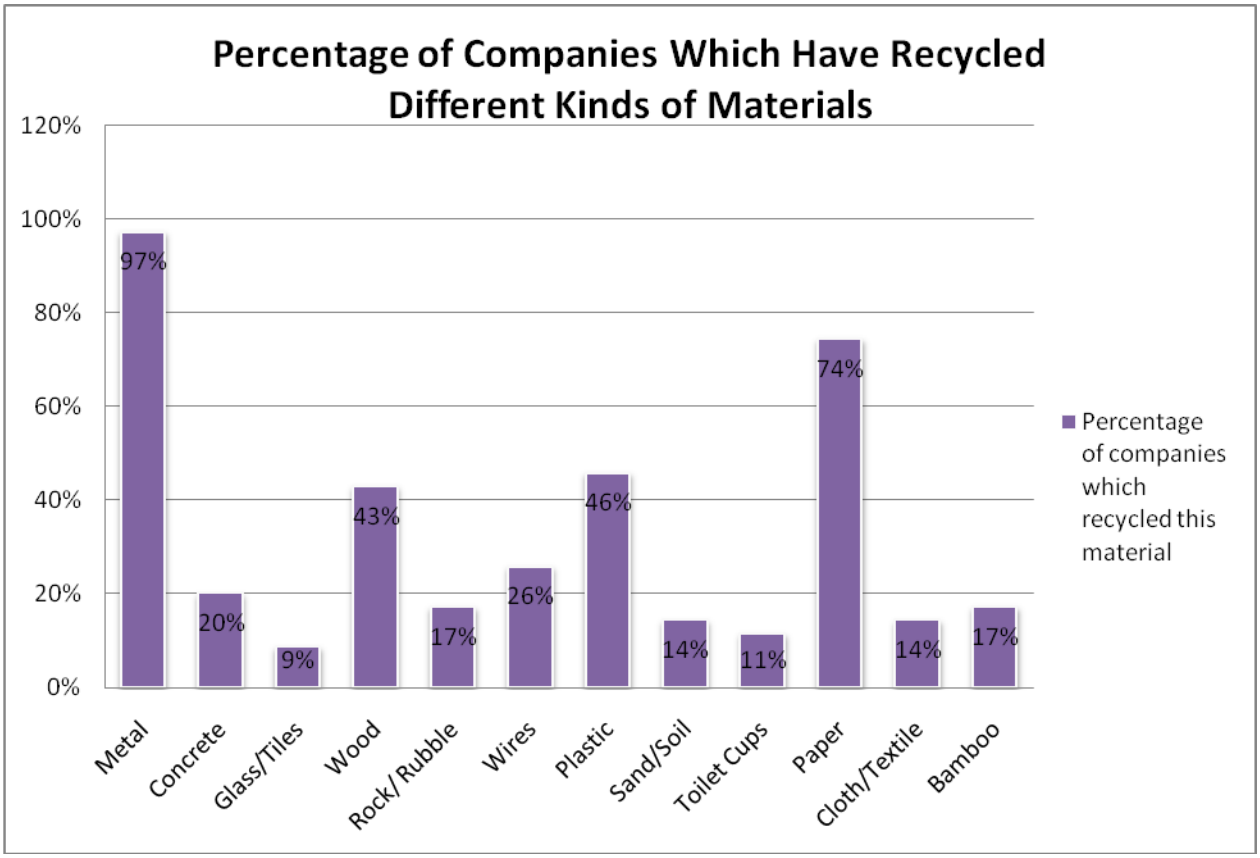


Figure 4-3. A bar chart showing the mean percentage of companies which have recycled different kinds of materials

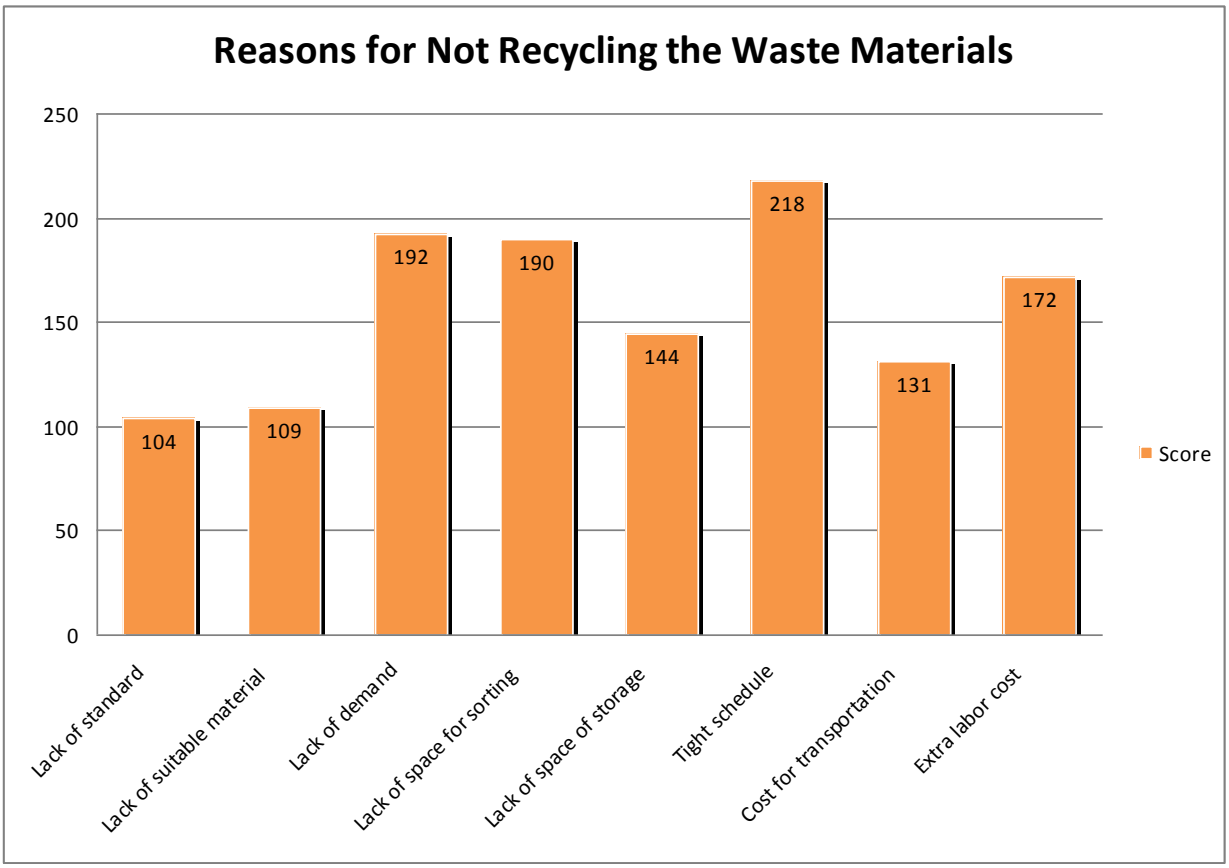


Figure 4-4. A bar chart showing the scores of the reasons for not recycling the waste materials

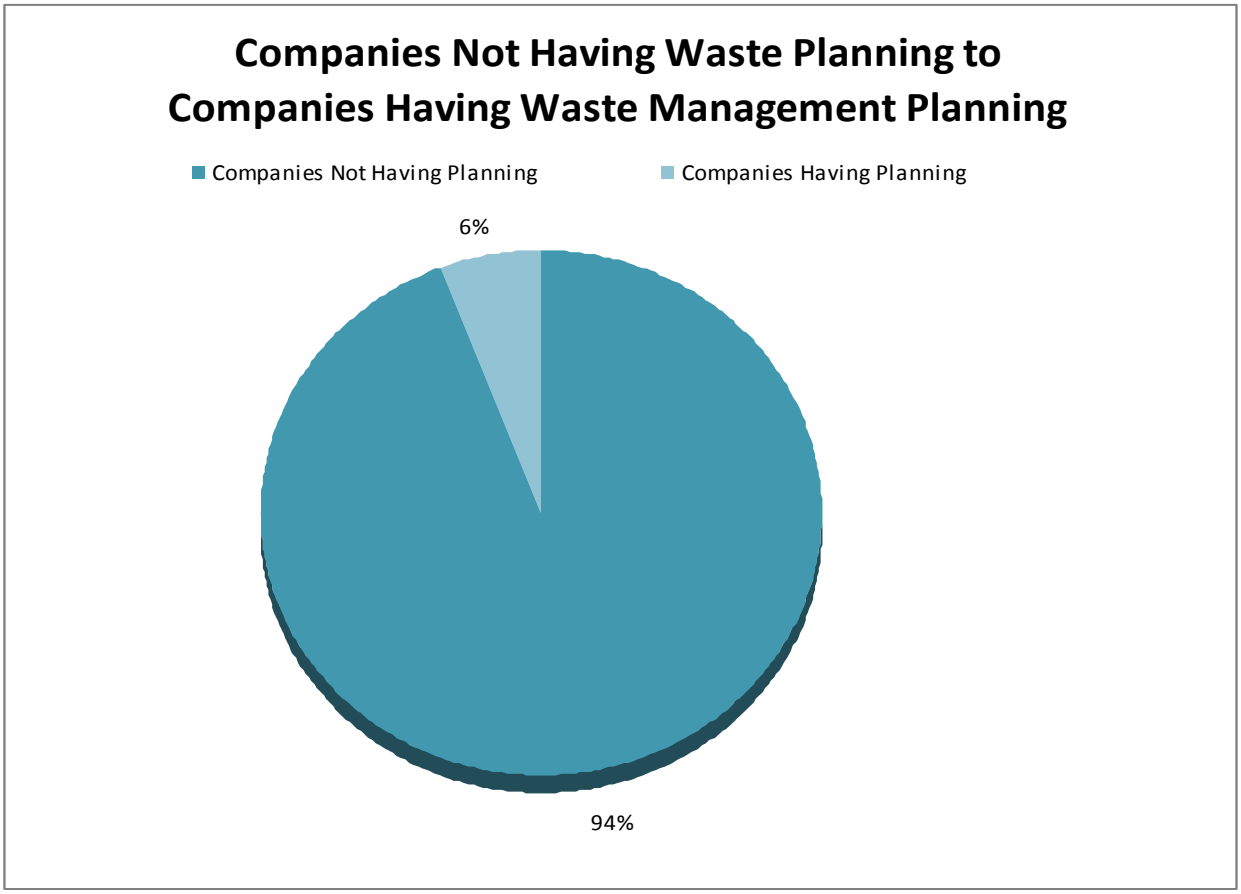
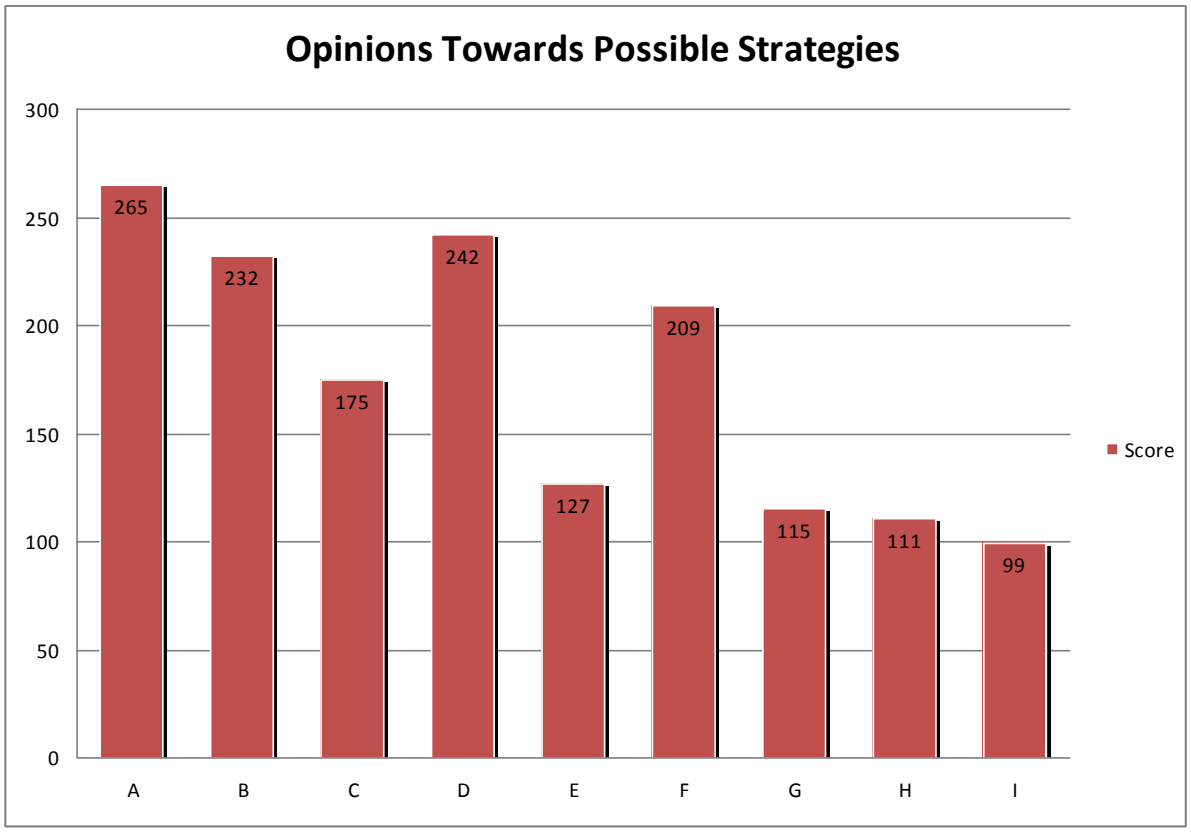


Figure 4-5. A pie chart showing the ratio of the companies having and not having waste management planning



Notes:

A. Legislations to mandate contractors a minimum percentage of C&D waste reuse and/or recycling in any construction projects.

B. Government subsidies the C&D waste reuse/recycling industries
C. Government promotes the development of C&D waste reuse/recycling technologies (e.g. converting reinforced concrete waste into recycled steel and recycled aggregates)
D. Government provides incentives to the contractors or developers with high percentage of C&D waste reuse/recycle (e.g. allows higher gross floor area to site area ratio, lower the tax rates, etc.)
E. Legislations to mandate the contractors to submit C&D waste management plan before the commencement of the works
F. Include a clause in the contract requiring a C&D waste management plan for both private and public projects
G. Provide guidelines and standard for C&D waste reuse and recycling
H. Increase the fees for disposal of C&D waste in landfill areas
I. The design professionals should plan for demolition in the design phase.

Figure 4-6. A bar chart showing the scores of the possible strategies

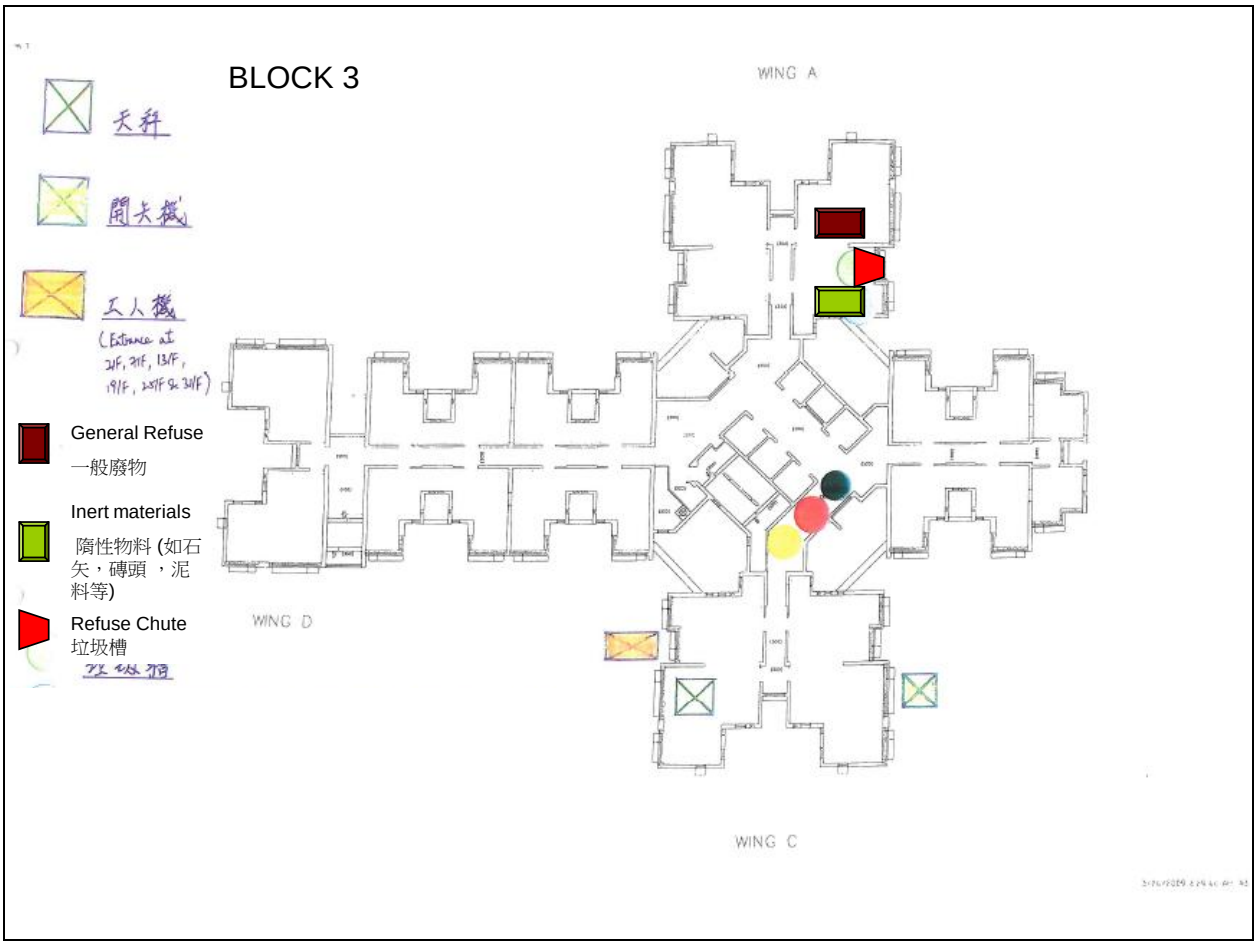


Figure 4-7. Layout Plan of Block 3

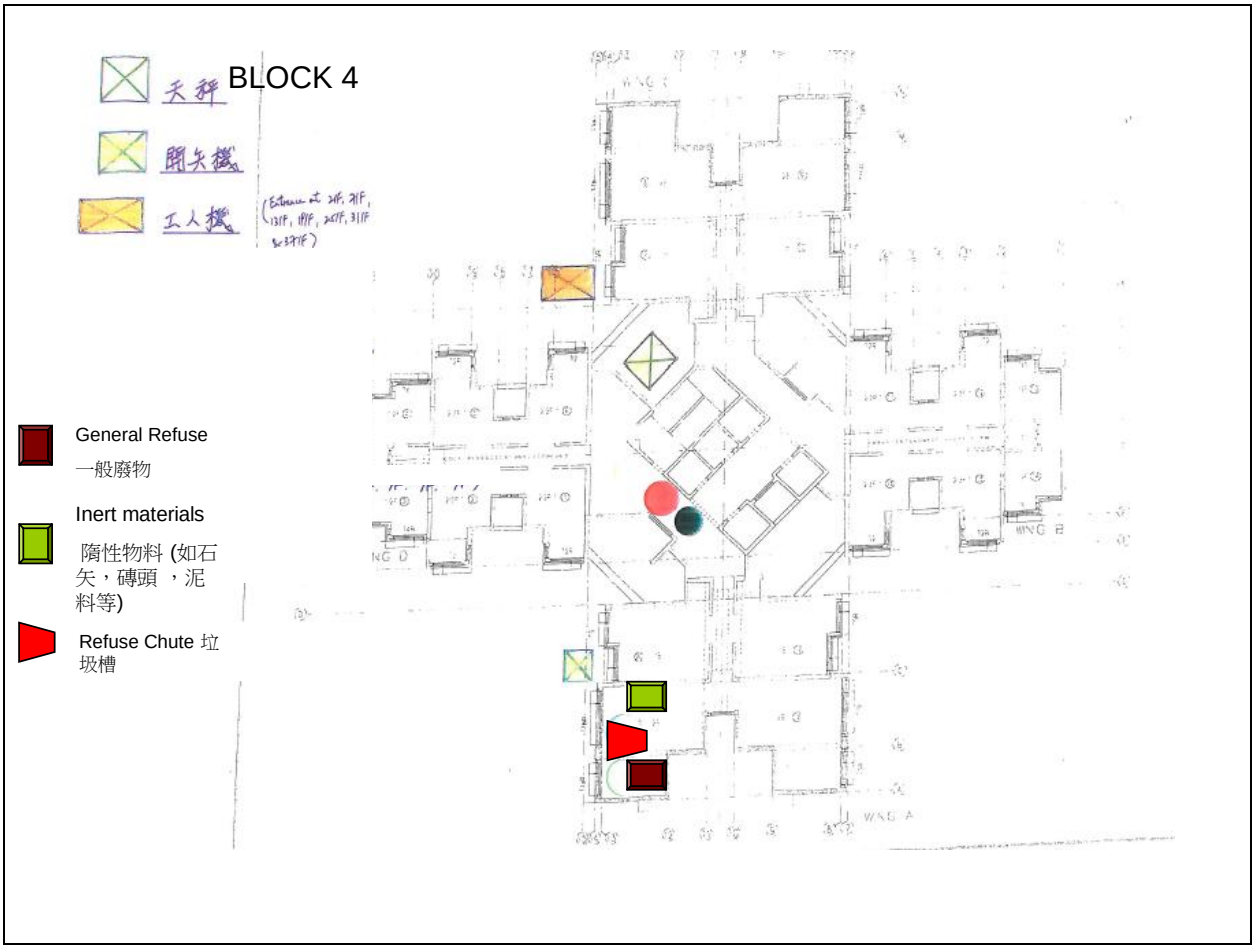


Figure 4-8. Layout Plan of Block 4

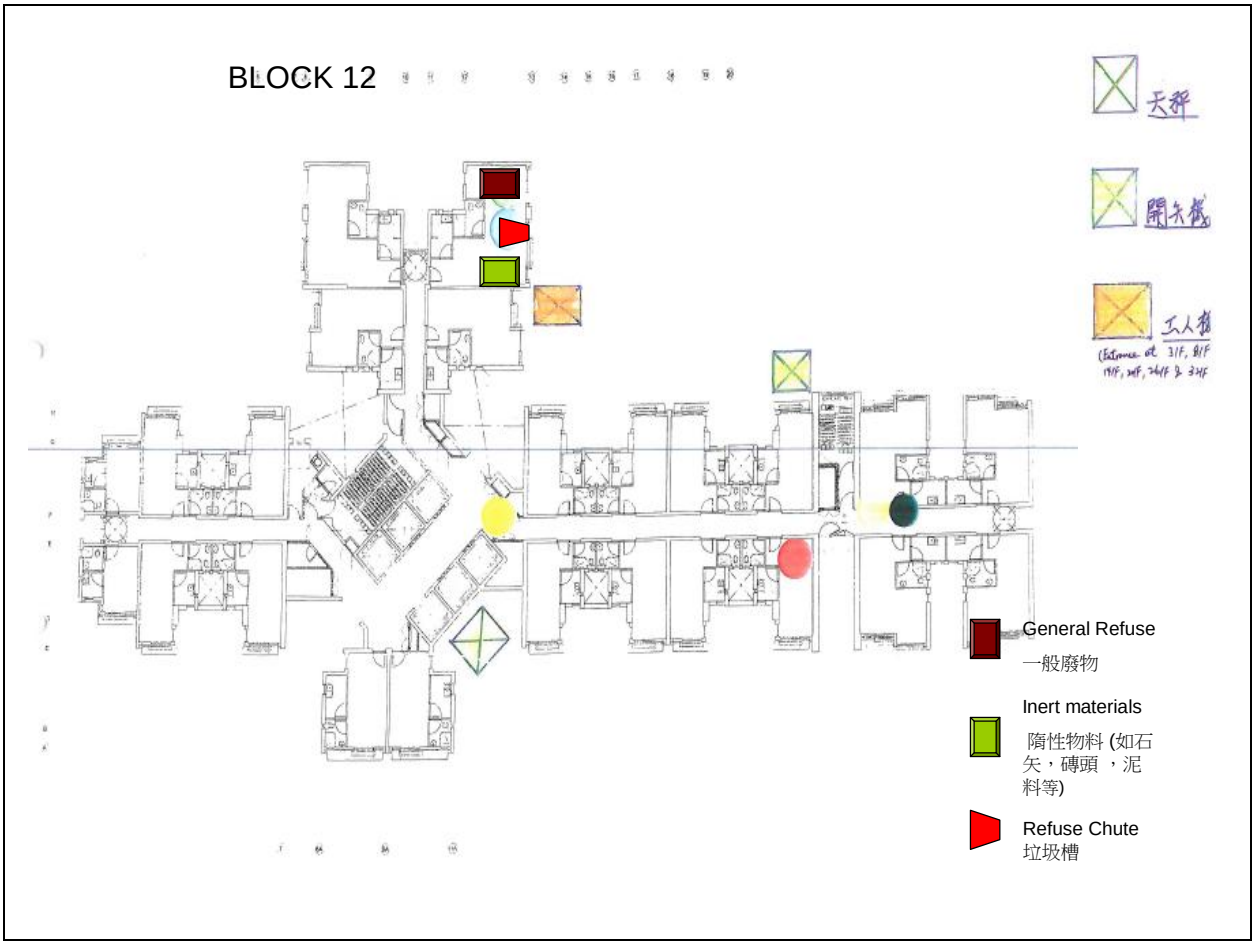


Figure 4-9. Layout Plan of Block 12

Figure 4-10. The refuse chute

Figure 4-11. Schedule for disposal of different kinds of C&D materials

Figure 4-12. Refuse collection point at ground level

Figure 4-13. Container used to store reusable or recyclable non-inert materials

Figure 4-14. Concrete piled up for sorting

Figure 4-15. Wire net used to screen out the large pieces of concrete

Figure 4-16. Metal scaffolding mounted on the façade

Figure 4-17. Aluminum formworks for suspended slab

Figure 4-18. Prefabricated facade system

Figure 4-19. Recycling boxes for collecting different kinds of waste materials

CHAPTER 5
RECOMMENDATIONS

Based on the findings of this research, recommendations on implementing construction and demolition waste management strategies were provided.

For Government

Legislations

The government could mandate contractors to reuse and/or recycle a minimum percentage of construction and demolition waste in any construction projects. This would make the contractors implement construction and demolition waste management in a certain level in order to achieve the legislative requirements.

However, this approach would only be practicable if there is a sound industry for recovering and recycling. The development of such industry is still very immature. Thus, to ensure the feasibility, the government should set a relatively low rate in the first several years (i.e. five percents), and then increase the minimum percentage by ten percents for every five years. This would allow enough time to the industrial participants for accommodating such policy.

Government Incentives

Government could provide different incentives in order to encourage the construction participants in implementing construction and waste management system. The developers or owners are interested in generating more rental income or profit in selling the properties. Thus, allowing the developers to develop the projects with higher gross floor area ratio would be an effective incentive.

As for the contractors, they are interested in reducing the construction costs and generate higher profit margin on the construction projects. Possible incentives would be

allowing a lower tax rate or a lower charge on using the public filling areas if they can meet certain requirements on waste management.

Subsidies for the Refurbishing/recycling Industries

The development of such industries is still immature. The recovering or recycling companies are only interested at the waste with high recycling value, like aluminum, steel and copper. The main difficulty for such companies is finding a suitable location for sorting and handling the waste. The refurbishing and recycling processes require the use of excessive space. However, the land cost in Hong Kong is generally high. Thus, apart from monetary subsidies, the government could lease out some land to the recovering or recycling companies with rental lower than current market price. Such location should be connected with waste and electricity supplies and easily accessed from the sources of waste.

For Developers

Contract Clauses

The developers could include a clause in the contract requiring the contractors to implement construction and demolition waste management for both private and public projects. The contracts may also include a penalty clause if the amount of waste exceeds the limit and a bonus clause if the contractors are able to control the amount waste in a certain level.

Adoption of Performance Assessment System

The developers, especially for those with large market shares, should adopt an assessment system to evaluate the performance of the contractors, the quality of the work and effectiveness in implementing construction and demolition waste management

system. Such system would then provide a basis to evaluate the overall performance of the contractor for selecting contractors in future procurement.

As for the developers with relatively low market shares, their projects may just be in one-off nature. Once their projects have completed, they could submit the result of the assessment to a pool. Every developer in the industry could be assessable to such pool to examine the past performance of the contractors. This would provide incentives for the contractors to implementing construction and demolition waste management system, since the contractors are interested in maintaining their goodwill within the industry.

For Designers

Consideration in Designs

The designers should consider waste reduction in the design phases. This could be achieved by matching the building elements with the standard dimensions of the building materials and using prefabricated elements to reduce the needs of temporary structures.

Using Recyclable or Recycled Materials

If possible, the designers should use recyclable or recycled materials in the designs. Example of this would be the specifications requiring the contractors to use concrete from demolition as the aggregates in road bases or sub bases in piling system. This would not only achieve sustainable development, but also increase the demand of recycled products in the market. This would help the development of the refurbishing and recycling industries.

For Contractors

Planning for Construction and Demolition Waste Management

The contractors should develop a plan for construction and demolition waste management before the commencement of the work. The purpose of the plan is to provide details of the means and measures for reducing the environmental impact of the construction waste generated throughout the execution of the work. The company should also ensure there are enough resources in implementation the measures. Such resources include money, manpower, and space in sorting and storing the waste. The plan would provide a comprehensive guideline for the subcontractors and employees to follow. Such plan should consist of the following items:

- Goals and objectives of the waste management system
- Organization structure for waste management
- Types and quantities of wastes would be generated during the execution of the work
- Timing of waste arising
- Procedures of handling different kinds of waste
- Layout plan for on-site waste sorting
- Areas for waste storage
- Monitoring and auditing program

CHAPTER 6
CONCLUSIONS

This research is aiming at providing an overview of the current situations of construction and demolition waste management practice in Hong Kong and formulating strategies on waste minimization.

The building industry consumes a considerable amount of resources. Those resources include valuable natural assets like timber and metal. Indeed, a large portion of the materials being wasted is due to poor material control on the building sites. Construction and demolition wastes are bulky in size and use up a large proportion of capacity if they are disposed of at landfills. Approximately 27% of the public landfill capacity in Hong Kong was used for handling with the construction and demolition waste in 2006. If this problem continues, the landfills in Hong Kong will be filled up in 5 to 9 years. Reducing and recycling construction wastes are therefore a key element of sustainability in future development.

Construction and demolition waste are normally sorted into two main portions: inert and non-inert. The strategies discussed in this research are mainly focused on avoiding waste, reusing materials and recycling waste. Near 80% of construction and demolition waste came from private projects and concrete was the most commonly found construction and demolition waste among all other categories. This is because most of the buildings in Hong Kong are commonly made up of reinforced concrete in both building structures and envelopes.

The research has described the current facilities for waste management in Hong Kong and the limitations in implementing construction and demolition waste management. The research has also discussed the strategies adopted in other

countries and other possible measures suggested by other researchers. The data of this research came from three sources: surveying the target group by questionnaire; interviewing with management staff of selected construction companies in Hong Kong; and a case study. The aims of the survey are to find out which kinds of waste are commonly reused or recycled and the views of industrial participants towards different waste management strategies, while the limitations in reusing or recycling the waste of various categories were discovered by interviewing. Strategies which had already been adopted in dealing with different kinds of waste by one of the leading construction companies in Hong Kong have been discussed in the case study.

The responding companies mainly reused metal, wood, wires, paper and bamboo in their sites. The mains reasons which made the responding companies not reusing the waste materials are the high recovery cost, lack of space for storage and lacks of special contractors to recover the waste materials in the market. The research also found that the construction companies were only interested at recycling the material with high value, like metal and paper. Most of responding companies did not have a plan designated for construction and demolition waste management. This would indeed be the biggest barrier in implementing the construction and demolition waste management in Hong Kong.

This research has provided several recommendations to different parties involved in the construction projects. Those parties include the government, developers, designers and contractors.

Further studies

Further studies could focus on the technical aspects in recycling concrete, minimum percentage of waste materials could be recycled and/or recovered in different

kinds of construction, and ways in helping the development of the recycling and refurbishing industries in Hong Kong.

APPENDIX A
SAMPLE OF THE SURVEY

Dear Sir or Madam,

I am a Master Degree student in University of Florida (USA). I am now working on a thesis related to construction and demolition waste management in Hong Kong. This questionnaire has been developed to determine the state of reuse and recycling of construction materials in Hong Kong. I would appreciate if you complete the survey and email/fax it to eramela@ufl.edu or (852)3106-8655 by 21ST September 2009. The results of the survey along with their analysis and conclusions will be provided to you upon completion of the study.
Definitions:
Reuse –*material being utilized in its original state more than once.*
Recycle – *process used materials into new products to prevent waste of potentially useful materials*
Construction and Demolition (C&D) Waste - *Waste arising from any land excavation or formation, civil or building construction, roadwork, building renovation or demolition activities.*

先生/女士：
本人是美國佛羅里達大學的碩士生，現正研究有關香港建築及拆卸廢料管理的問題。此問卷是用作調查目前香港循環再造及重用建築及拆卸廢料的情況。有關研究完成後，研究結果及分折將會提供給閣下。請將回覆於二零零九年九月二十一日或之前電郵至 eramela@ufl.edu 或傳真至(852)3106-8655。

釋義：

重用 *– 是指用關物料翻新後直接使用其原始狀態不少於一次*
循環再造 - *是指收集本來要廢棄的材料，分解再製成新產品*
建築及拆卸廢料 – *由任何土地平整、民事或建築工程、道路工程、建築裝修或拆卸活動所產生的廢物*

Please circle/highlight the appropriate answers. 請圈出適當的答案。

1. Which of the following materials have been reused in your construction projects? (You may choose more than one option). Please also provide a rough percentage (%) of waste that was reused for each kind of material.
   哪幾種建築及拆卸廢料曾經被再重用(翻新後直接安裝)?大概多少個百分比的物料被重用?(可選多過一個答案)

Metal 金屬	___%	Concrete 石屎	___%	Glass/Tiles 玻璃/瓷磚	___%
Wood (timber /plywood) 木材	___%	Rock/Rubble 石頭	___%	Wires 電線	___%
Plastic 塑膠	___%	Sand/Soil 砂/土	___%	Toilet Cups 坐廁	___%
Paper 廢紙	___%	Cloth/Textile 布	___%	Bamboo 竹	___%

Others(please specify:_____)其他:_____ ___%

2. Rank the following reasons (from 1 to 8) for not reusing construction materials.
   哪些因素是最阻礙推行建築及拆卸廢料再重用？請排出(1-8)

Costs for recovery
翻新廢料費用昂貴 ____

Contract requirements
合約要求用新的物料 ____

Lack of suitable materials
沒有合適的物料 ____

Lack of specialty contractors for salvaging materials for reuse
沒有公司/外判商去翻新廢料 ____

Lacks of space for sorting
工地沒足夠地方將廢料分類 ____

Lacks of space for storage
工地沒足夠地方儲藏廢料 ____

Tight Schedule
合約時間緊迫 ____

Lacks of standard for reuse
沒有標準說明哪些廢料可重用 ____

Others (please specify:_____)
其他:_____

3. Which of the following materials have been recycled in your construction projects? Please also provide a rough percentage (%) of waste that is recycled for each material. (You may choose more than one option)
哪幾種建築及拆卸廢料曾經被循環再造？大概多少個百分比的物料被循環再造？(可選多過一個答案)

Metal 金屬 ___%	Concrete 石屎 ___%	Glass/Tiles 玻璃/瓷磚 ___%
Wood (timber /plywood) 木材 ___%	Rock/Rubble 石頭 ___%	Wires 電線 ___%
Plastic 塑膠 ___%	Sand/Soil 砂/土 ___%	Toilet Cups 坐廁 ___%
Paper 廢紙 ___%	Cloth/Textile 布 ___%	Bamboo 竹 ___%

Others (please specify:_____)其他:_____ ___%

4. Rank the following reasons (from 1 to 8) for not recycling construction materials.
甚麼因素是最阻礙推行建築及拆卸廢料循環再造？請排出 1-8

Lack of standard for recycling
沒有標準說明哪些廢料可循環再造 _____

Lack of suitable materials
沒有合適的物料 ____

Lack of demand of recycled products 市場內並沒有回收廢料的需求 _____

Lack of space for sorting
工地沒足夠地方將廢料分類 _____

Lack of space for storage
工地沒足夠地方儲藏廢料 _____

Tight Schedule
合約時間緊迫 _____

Costs for transportation
運輸成本昂貴 _____

Extra labor cost
要付額外的工時 _____

Others (please specify:_____)其他: _____

5. Does your company have any C&D waste management plan for construction projects?
貴公司有沒有建築及拆卸廢料管理計劃書？
   A. Yes 有 (Would you please provide us a copy of the plan 如方便的話，請提供一份副本)
   B. No 無

6. Rank the following recommendations (from 1 to 8) to promote reuse and recycling of C&D waste materials in Hong Kong?
你認為下列那個是最可行及有利推行建築及拆卸廢料重用或循環再造的方案？(請排出 1-9)
   A. Legislations to mandate contractors a minimum percentage of C&D waste reuse and/or recycling in any construction projects.

應立法強制承建商推行建築及拆卸廢料重用或循環再造 ____

B. Government subsidies the C&D waste reuse/recycling industries
政府應支援從事建築及拆卸廢料翻新或循環再造的工業 ____

C. Government promotes the development of C&D waste reuse/recycling technologies (e.g. converting reinforced concrete waste into recycled steel and recycled aggregates)
政府應推動建築及拆卸廢料翻新或循環再造的科技發展 (例如：用機器打碎石屎，循環鋼筋，並將水泥循環再造成石粒) ____

D. Government provides incentives to the contractors or developers with high percentage of C&D waste reuse/recycle (e.g. allows higher gross floor area to site area ratio, lower the tax rates, etc.)
政府應鼓勵承建商或發展商推行建築及拆卸廢料重用或循環再造(例如：承建商或發展商可享退稅優惠或可建更多的樓面面積) ____

E. Legislations to mandate the contractors to submit C&D waste management plan before the commencement of the works
強制承建商在工程進行前提交建築及拆卸廢料管理計劃書 ____

F. Include a clause in the contract requiring a C&D waste management plan for both private and public projects
合約上應加插有關建築及拆卸廢料管理的條款 ____

G. Provide guidelines and standard for C&D waste reuse and recycling
制定指示去說明哪些廢料可循環再造或重用 ____

H. Increase the fees for disposal of C&D waste in landfill areas
增加使用堆填區或填土區的費用 ____

I. The design professionals should plan for demolition in the design phase.
設計專業人員(如建築師、工程師)應在設計階段計劃如何拆卸整棟樓房 ____

7. Please provide other recommendations for increasing reuse and recycling of construction materials in Hong Kong.
請提供其他可行的方法以助提高建築及拆卸廢料循環再造及重用比率。

_____

_____

Please e-mail/fax your responses to: Josefina Eramela (eramela@ufl.edu)/ (852)3106-8655

請將回覆電郵至 eramela@ufl.edu 或傳真至(852)3106-8655。

Thank you very much for your responses.
感謝您的回覆。

Best Regards,
Wing Yi Josefina Eramela

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BIOGRAPHICAL SKETCH

Wing-Yi Josefina Eramela was born in Hong Kong. After graduating from the Hong Kong Polytechnic University with a Bachelor of Science (Hons) in Surveying, she decided pursue a higher education in America. Wing-Yi graduated with a Master of Science in Building Construction in University of Florida in December 2009 and intends to be an estimator in the construction industry.