A Critical Review of Hong Kong's Construction and Demolition Waste Management Program

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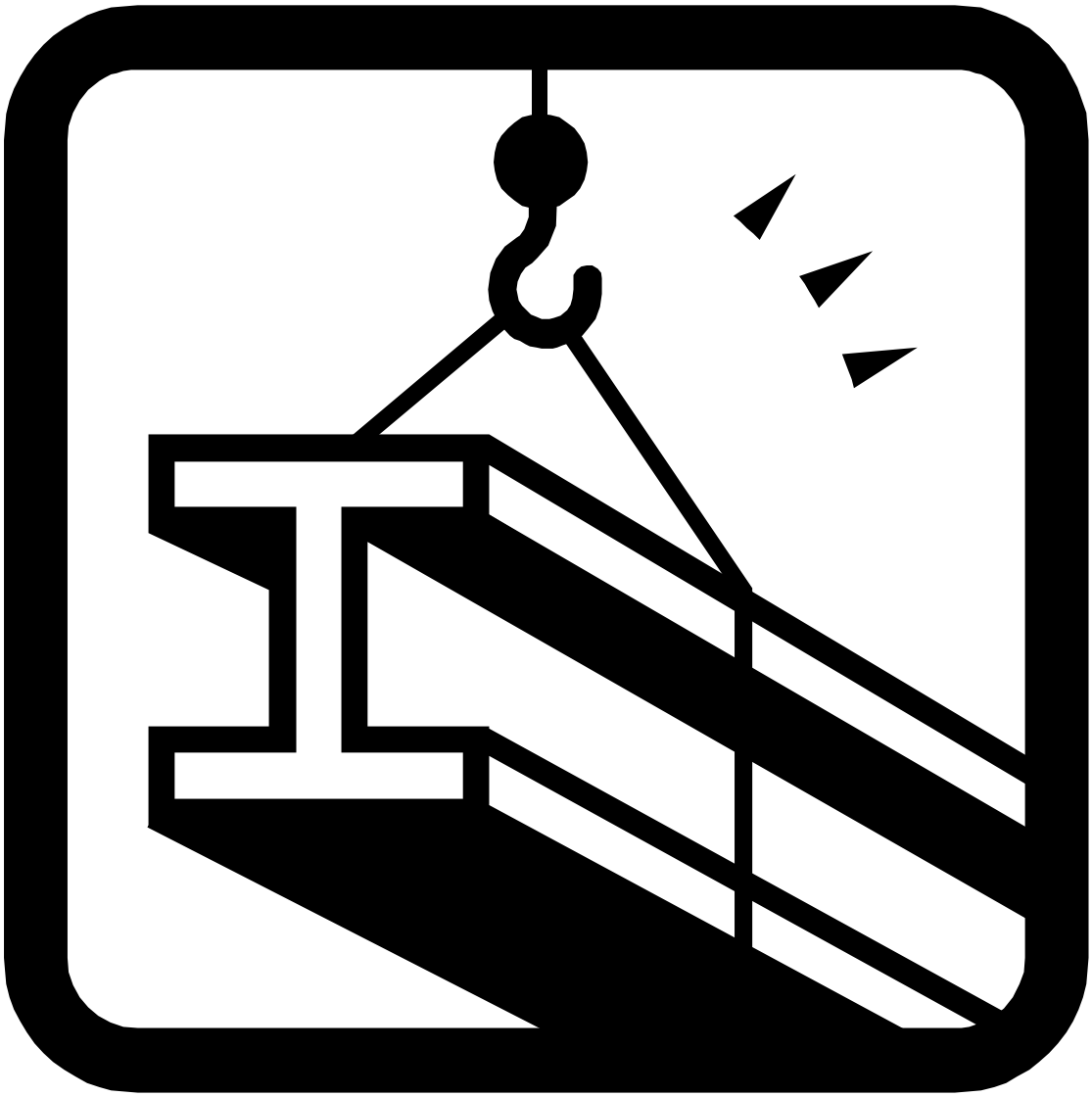

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A Critical Review of Hong Kong Construction and Demolition Waste Management

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Abstract

Construction and demolition (C&D) waste is a major contributor to the high volume of refuse in Hong Kong. A critical review of Hong Kong's C&D waste management was carried out using information gained from interviews, observations, and policy analyses. Based on the acquired data, the team determined that the situation required attention and repair. In order to remedy the problems, recommendations including instituting tipping fees, creating recycling plants, employing environmentally friendly deconstruction methods, developing waste minimization programs, and increasing communication were provided.

Acknowledgements

This project could never have been completed without the knowledge shared by the many people discussed in this section. These people provided not only the information on the many topics in the project but also a friendly face while in Hong Kong.

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Executive Summary

With space diminishing in Hong Kong landfills, the government ascertained a major contributor to the high volume of refuse: construction and demolition (C&D) waste. This report provides a critical review of Hong Kong's current program and proposes possible ways to improve its C&D waste management. In order to prevent the large amount of C&D waste arriving at landfills, diversionary practices must be instituted. Currently, the government is researching different possibilities, and this report provides a concise examination of the current situation and recommendations for the industry to institute.

To accomplish the critical review, research on selected cities' and countries' recycling programs throughout the world was done to provide useful information as to how other governments are handling their waste management. This research showed how New York City has tipping fees on its waste, and that cities like Vaasa, Finland, are working toward complete sustainability. Additionally, the current technology in the field of recycling was researched, exhibiting that factories are taking timber and outputting a clean-burning fuel in the form of wooden pellets. The final research during this phase was applications for the products of C&D recycling. Recycled aggregate for walkways and broken-down inert material for roadways are two examples of such uses.

While in Hong Kong, interviews with members of the government, industry, environmental groups, and the education community were conducted to obtain information on Hong Kong government's policies,

planned construction projects, and waste reduction efforts. Furthermore, direct observation of what is actually done with waste at construction and landfill sites was carried out. Additionally, comparative analysis of policies in New York City and Taipei was completed. Finally, based on the information gained from the interviews and research on other countries' waste management programs, possible suggestions to improve Hong Kong's situation were made. This information was divided into main topics within the subject, including tipping fees, recycling, sorting, and waste minimization.

Tipping fees are essential in order to make Hong Kong's waste management more successful. If contractors do not have an incentive to reduce the waste that they generate, then C&D waste will continue to build up over time. Tipping fees are established in most cities around the world, and Hong Kong should not be an exception. The interviewees also agreed with the instituting of tipping fees as a method of diversion of waste from landfills.

The most important and productive method of waste removal is reducing the waste that is generated. The Environmental Protection Department (EPD) has introduced a Waste Minimization Plan to reduce the amount of C&D waste generated. It was found that in other countries, such as Taiwan, similar plans were in place and were working more effectively than those in Hong Kong. However, with the proper execution of the Hong Kong waste minimization plan, C&D waste can be reduced significantly in the future.

About 36,000 tonnes of C&D materials are generated per day. Roughly 30,000 tonnes of materials are sent to public fills while 6,000

tonnes are mixed waste and must be sent to landfills. C&D material stored in public fills is made up of inert construction material, such as concrete and brick. Material stored in public fills is mainly used for reclamation or earth filling projects. Unfortunately, public fill is not fully utilized by such projects, and as a result, public filling areas are filling up rapidly. In order to remedy this, a permanent solution to the problem must be found. Currently, the government is looking at building a temporary holding area in Tuen Mun. Interviewees felt, though, that this measure will not fix the problem but merely delay its intensity. A better solution would be to build a permanent public fill sorting and stockpiling area.

C&D waste constitutes over 40% of the total waste brought to landfills. By sorting the C&D waste, a significant portion of the material brought to landfills will be reduced. As construction sites in Hong Kong have very limited space, interviewees felt that an off-site sorting area must be provided to facilitate the sorting of material to be sent to recycling plants and landfills. It was found that in other cities, like New York City and Taipei, both on- and off-site sorting was used. Similar methods should be put into place to help facilitate the recycling and reuse of this material.

Many of the materials stored in public fills can be recycled into concrete and brick for building construction. To use recycled concrete, there must be policies ensuring the safety of the material. In order for Hong Kong to create a market for such material, it must put such policies in place. This will allow the industry to utilize this material and will facilitate the increase in use of such material.

There are additional alternatives to managing C&D waste. One of them is to create small incinerators to burn timber to reduce such wastes. Another alternative is to export waste into areas such as Mainland China. This may be costly, but it is an alternative with the least negative side effects for Hong Kong. A final alternative is the creation of a 700-hectare waste island off Lantau formed from C&D waste and used as a landfill or public fill stockpiling area. This should only be implemented as a last resort solution.

As Hong Kong continues to enjoy economic growth, construction and demolition projects will carry on. With public fill areas running out by the end of this year (2002) and landfill space decreasing rapidly, the government must seriously consider instituting the recommendations provided here and allow itself to be fully prepared for what lies ahead.

Authorship

For the report, the work was divided evenly among the three group members. Sections were divided between the members, with one person writing a draft and then the other two group members proofreading it. This enabled the team to be in agreement with what was written. Subsequent drafts were then rotated around the group for revisions and updates.

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Chapter 1. Introduction

Waste disposal is one of the greatest environmental problems of today's world. No longer can industry release any amount of contaminants into the surrounding air, water, and land without unfavorable effects. In the past, disposing of waste in landfills was considered acceptable. However, today landfills are being closed because they cannot meet environmental standards or are contaminating groundwater or surface water. Some are being closed simply because they are full. With the ever-decreasing space to store waste, cities and countries have been forced to adopt serious waste management programs. It is the job of these programs to divert waste from landfills by adopting waste recycling and reduction methods. One form of waste that requires investigation, especially for developing countries, is that generated by construction and demolition (C&D).

Hong Kong is one city that has a large amount of construction waste. It is noted in a paper by the Legislative Council Panel on Environmental Affairs entitled "Management of Construction and Demolition Materials," (Environment and Food Bureau, 2001) that between 1991 and 1999, the amount of C&D materials produced annually by local construction activities increased by more than 75% from about 7.7 million tons to 13.5 million tons. A good portion of the C&D waste ends up in landfills, and unfortunately Hong Kong has very limited landfill space and is therefore seeking solutions to limit the amount of C&D waste that is placed there. Figure 1.1 shows the distribution of Hong Kong's waste stream.

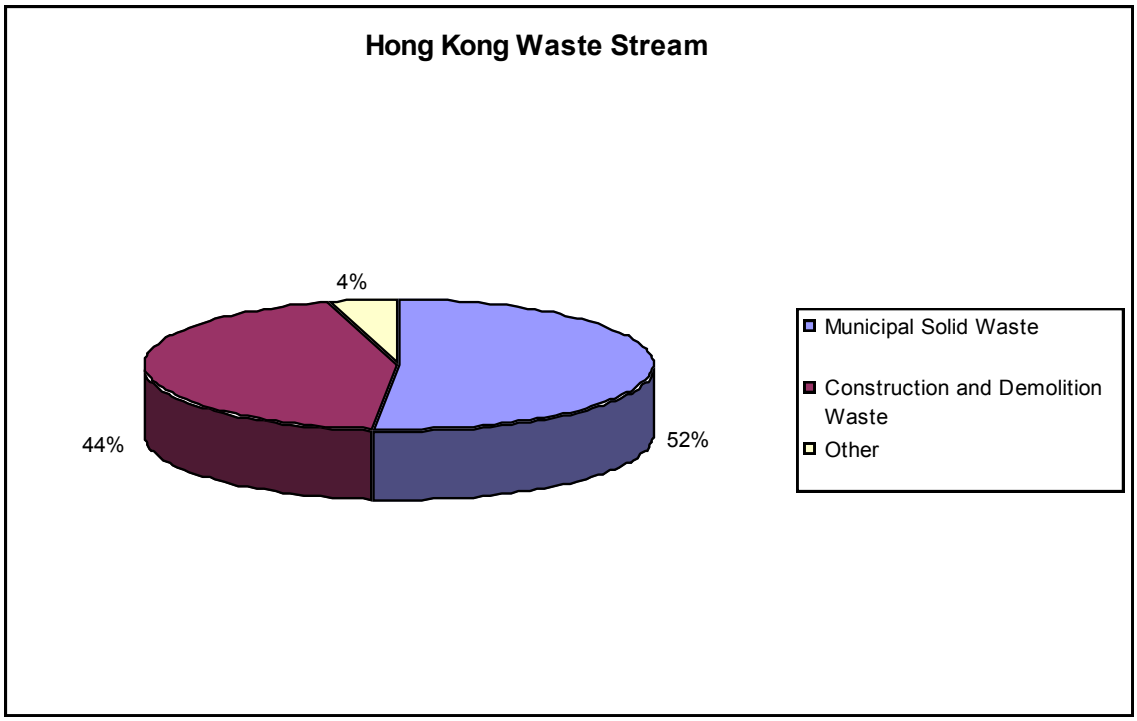


Figure 1.1. Distribution of Hong Kong's waste stream

Civic Exchange is one organization in Hong Kong that is very concerned about the current C&D waste management problem. As stated on their organization website, Civic Exchange is an independent, non-profit, public policy think-tank (Civic Exchange, 2001). The goals of the organization are to promote civic education and public awareness and to participate in governance. The organization also undertakes research and development in economic, social, and political policies and practices to help shape the breadth and depth of public policy debate. Civic Exchange has chosen to sponsor this project because C&D waste management is a very serious environmental issue in Hong Kong.

This report provides a critical review of Hong Kong's current C&D waste management program and proposes possible ways to improve it. To accomplish the critical review some important steps were taken. Research on selected cities' and countries' recycling programs

throughout the world was done to provide useful information as to how other governments are handling their waste management. Also, the current technology in the field was researched, and uses for the products of C&D recycling were explored.

While in Hong Kong the team conducted interviews with members of the Environmental Protection Department, Waste Reduction Committee, and Civil Engineering Department. Interviews with members of these groups provided information on Hong Kong government's policies, planned construction projects, and waste reduction efforts concerning C&D waste management. Interviews with people in the construction industry were also conducted to understand on-site practices better. In addition, the team conducted interviews with members of Hong Kong's "green" groups and academics to get their opinions on C&D waste management. To complement the information attained from our interviews, direct observation of what was actually done with waste at construction and landfill sites was carried out. Finally, based on the information gained from the interviews and research on other countries' waste management programs, possible suggestions to improve Hong Kong's situation were made.

Chapter 2. Literature Review

The purpose of this Literature Review is to provide background information on the topic of Construction and Demolition (C&D) waste management, which will allow for assessment of the information pertaining to current C&D waste techniques, policies, and programs. This information provides a foundation on which a full critical review of Hong Kong's current C&D waste management was performed.

The topics reviewed include concepts of recycling, C&D waste reduction, the current technology in C&D recycling, government policies concerning C&D recycling, markets for C&D recycled materials, and public acceptance of C&D management. Within these topics, different cities' techniques for C&D recycling were studied, including New York City, NY, USA; Los Angeles, CA, USA; and Vaasa, Finland. These places have been chosen for both their recycling techniques and/or their similarity to Hong Kong.

2.1. Concepts of Recycling

Throughout the world, there are some general concepts and goals of recycling programs. One goal is to have zero pollution, while another is to reach a sustainable state of development. Before those can be achieved, a city must first implement a plan for a successful waste management program.

2.1.1. Zero Pollution

Recently there has been a push for zero pollution standards (Nemerow, 1995). Zero pollution requires that industry remove all pollutants from its output streams. Industry can achieve zero pollution utilizing three main methods. One method is recovery and reuse within the same plant to minimize waste as much as possible. Ideally, a company could reduce its pollutants to be next to none. In reality, though, only twenty-five to seventy-five percent reduction is all a company can achieve due to factors such as minimal contribution and products that cannot be recycled.

Another method is the recovery and sale of wastes to other manufacturers outside of the company (Nemerow, 1995). The method works where the by-products of one company can be used as raw material for another company. For example, phosphate fertilizer companies produce large amounts of calcium as a by-product, and the cement industry uses calcium to produce calcium oxide cement. Thus, instead of disposing of its calcium by-product, a fertilizer company could sell it to a cement-making company.

A third method combines the first two methods by putting the waste producer and user together within the same complex (Nemerow, 1995). This method is the most ideal of the three methods for zero pollution. The big benefit of this method is that it reduces the transport costs between the waste producer and user. In order for this method to be the most effective, though, the user's operations must be compatible with that of the producer's. Thus, the proper selection of compatible

industrial plants is necessary to ensure that a workable and efficient complex is formed.

2.1.2. Sustainable Development/Construction

The construction industry affects the environment in positive ways by providing physical means for improving and/or protecting the environment (Ofori et al., 2000). Unfortunately, construction also has negative effects on the environment, including various forms of environmental pollution, resource depletion, and loss of biodiversity. It is the job of the construction industry to meet the increasing human needs for shelter and facilities for production, services, and leisure. In addition, natural resources essential for future development must be conserved. Thus, a new methodology for construction, called sustainable construction, has been created. Sustainable construction fits into a larger methodology called sustainable development.

Sustainable development can be defined as "development, which meets the needs of the present without compromising the ability of future generations to meet their needs" (Ofori et al., 2000, p. 2). Although this is a common definition for sustainable development, not everyone agrees with it. Some interpret the words 'sustainable development' to mean, "as long as development is sustained, economic growth will continue and environmental issues will be dealt with through technology" (Ofori et al., 2000, p. 2). There are many other definitions for sustainable development as well. The myriad definitions are because different languages and cultures hold different meaning of the words 'sustainable' and 'development'. As a result, each country or city usually

defines what sustainable development means specifically for its unique circumstances.

Construction plays a major part in a city's development (Ofori et al., 2000). The results of construction provide shelter, commerce, and production. Construction also has considerable and irreversible effects on the environment including the following:

- Use of land for landfills in competition with other activities such as agriculture;
- Use of virgin land such as forests, wetlands and coastal areas, which often implies loss of biodiversity;
- Massive use of natural resources, many of which are non-renewable;
- Pollution of air during the transportation of materials and site activity;
- Consumption of water and pollution of water reserves;
- Generation of waste owing to poor resource management;
- High energy consumption on site and in completed facilities;
- Generation of noise by site activity; and
- Breeding of pests, such as mosquitoes and rodents, owing to poor housekeeping on site (Ofori et al., 2000, p. 3)

Since construction significantly affects the environment, the term 'sustainable construction' has been defined to describe how the construction industry can play a role in the sustainable development effort (Ofori et al., 2000). Sustainable construction can be defined as "the creation and responsible management of a healthy built

environment based on resource-efficient, ecologically-based principles" (Ofori et al., 2000, p. 2). As part of sustainable construction, construction companies should plan for the full lifetime of a building, that is, from its initial construction to its inevitable destruction. All buildings and structures should be built such that they are sustainable in environmental, economic, and social terms as well as add to the value of life.

Sustainable development and zero pollution are two main topics within the realm of recycling. For cities to implement a successful recycling program with these ideas in mind, the five steps of a waste management program must be implemented.

2.1.3. Plan of Action

The goal of a waste management program is to change the behavior of those who generate waste so that they routinely transport, treat, and dispose of it in an environmentally safe manner (Probst and Beierle, 1999). Developing an effective waste management program typically requires the following steps: identification of the problem and enacting legislation; designation of a lead agency; promulgation of rules and regulations; development of treatment and disposal capacity; and creation of a mature enforcement program. Each step may take a number of years, and at each step there are many difficult issues to resolve. Even though all countries pass through the same five steps of program development, no two countries follow precisely the same path. Differences in geography, demographics, industrial profile, politics, and culture cause countries to make different decisions at each step.

The first step in developing a waste management program is identifying whether the present waste disposal practices are harming the environment and if so, then what legislation must be enacted to improve waste management. Recognizing the problem usually happens after a catalyzing event. The publication of the white paper Pollution in Hong Kong: A Time to Act in 1989, which focused the region's attention on the problem of hazardous waste and led to the development of hazardous waste regulations, is an example of a catalyzing event (Probst and Beierle, 1999). Once a problem has been identified, an agency or agencies must be appointed to address the problem.

To ensure that the appointed agency or agencies can ameliorate the current situation, at least four issues need to be addressed (Probst and Beierle, 1999). First, the agency must have the power to regulate. Second, the agency's regulatory responsibilities must be clearly outlined with regard to how the responsibilities will be shared among national, state, and local authorities. Third, it must be determined whether authority is solely possessed by one agency or distributed among agencies with a variety of responsibilities. Last, such agencies must have sufficient financial, technical, and human resources to carry out their tasks.

Once laws are enacted to control waste management and an agency is appointed, regulations and requirements must be developed (Probst and Beierle, 1999). The first step in developing regulations and requirements is to determine which wastes will be regulated. Which wastes are regulated depends greatly on the specific country. For example, Hong Kong has a large amount of C&D waste, and therefore

there is much concern on how it can be limited. For other countries that are not developing as rapidly as Hong Kong, regulating demolition and construction waste may not be as important. After it is determined which wastes are to be regulated, requirements for waste generators are set as to how they should store and dispose of their waste. Furthermore, such items as fines, penalties, and enforcement actions are put in place.

The next step in implementing a waste management program is to develop enough disposal, treatment, and recycling facilities to handle the country's waste stream (Probst and Beierle, 1999). This step does not necessarily occur sequentially with the other steps because building disposal, treatment, and recycling facilities takes time. Ideally, once regulations for waste management come into place there should be adequate capacity for the current stream of waste. If there is insufficient capacity to handle the waste, companies will not be able to meet the government's requirements. Unfortunately, waste facilities are costly to build and other factors, such as where the facilities are to be built, must be well thought out.

For the final step to be accomplished all the previously described steps must be achieved (Probst and Beierle, 1999). A governing agency is in place, laws have been made, regulations have been implemented, and there is sufficient disposal/treatment/recycling capacity. In addition, to have an effective regulatory system there must be a "culture of compliance" (Probst and Beierle, 1999). If it is culturally accepted and expected to handle waste in an environmentally safe way, then companies will store, transport, treat, recycle, and dispose of their waste in a proper manner without the need for direct government involvement.

In order for a regulatory program to have a culture of compliance, it must have enough public support so that companies comply. Public compliance with a regulatory program is usually achieved by making the threat of enforcement real. In addition, the success of a country's waste management system depends on a country's political and legal culture. With a successful waste management program in place, it is possible to strive for the ideas of zero pollution and sustainable development. With the general topics of recycling understood, specific ideas within construction and demolition management can be discussed.

2.2. Ways to Reduce C&D Waste

In order to lessen the amount of demolition and construction waste produced, construction sites can use waste reduction methods that help reduce the amount of waste coming from that site (Fishbein, 1998). Inert material, such as brick and concrete, can be crushed up and reused as fill, driveway bedding, and landscape covering. To reduce the amount of timber used, a special cutting section of the construction site can be designated so that cut-offs can be used when possible instead of fresh pieces of lumber. Gypsum drywall scraps can be put into walls with insulation to aid in soundproofing. Carpet leftovers can be cut up into mats and small rugs or can be reused in areas where aesthetics may not be very important, such as basements and attics.

One of the largest components of construction waste is packaging waste (Fishbein, 1998). This is material used as containers and bindings for material coming into construction and demolition sites. In 1991, Germany instituted an Extended Producer Responsibility (EPR) plan,

which forced the producers of the material being shipped in this packaging waste to be responsible for its collection and recycling. By doing this, companies reduced the amount of packaging material they used since they were then responsible for its disposal. By reducing this packaging waste, the overall amount of construction and demolition waste can be decreased.

2.3. Technology of C&D Recycling

In order to maintain control of the growing recycling problem, researching current recycling technologies around the world should be beneficial to other nations and cities, which can adopt such methods (Hong Kong EPD, 2001). Paper, cans, and bottles are the most common products being recycled in the United States. In 1993, the United States recycled 17% of the nation's waste while the world's leading recycling nation, Germany, was recycling 30%. Both nations have significantly improved their recycling rate since that time. However, both nations are also the two most capable of investing vast amounts of funding necessary for their recycling programs.

2.3.1. Vaasa Project

Vaasa, a small city in Finland with a population of 55,000 citizens, has developed a very economically friendly system, which can reduce their waste by 92% (Fujita, 1999). The goal originally set for the new treatment system was to reduce the quantity of waste disposed in landfills by 70%, and this was to be achieved by six methods:

- Sorting of waste
- Achieving high recovery of metals, furniture and other recyclable goods
- Using biodegradable waste to produce biogas and humus (soil)
- Using biogas produced as fuel in electricity generation
- Using produced humus in park maintenance
- Burning combustible waste to produce electricity

The heart of the Vaasa project is the Stormossen waste treatment plant (Fujita, 1999). After the waste materials are separated (and mechanically screened) the biological treatment of the waste begins. Thermophilic treatment of the waste results in the production of hygienic humus mass (soil). The soil produced has high levels of nutrients and is particularly suitable for use in the city's parks and recreation areas. Due to good source separation of waste, the heavy metal content of the soil is very low, and it can be sold for use as a fertilizer on both agricultural and forestry land. The Stormossen plant also produces significant amounts of Vaasa's electricity. Each ton of bio-waste treated yields between 100 and 150 cubic meters of biogas. The gas is 60-70% methane and burns cleanly to produce 6-7 kWh of electricity per cubic meter. Some 20% of this energy is used internally, to keep the plant operating, while the other 80% is converted into electricity for use in Vaasa.

The Pietarsaari pellet plant is the second plant of the Vaasa program and was put into operation to handle waste that was not treated at Stormossen (Fujita, 1999). The plant now handles all of Vaasa's burnable waste (paper, cardboard, etc.), processing it into small pellets.

The pellets are then sold to a local paper mill, where they replace imported coal as a clean fuel.

The final component in the system is the Ekokeskus, Vaasa's environmental center (Fujita, 1999). Ekokeskus operates as both a recycling point and an advice bureau for the city's citizens. One key aim of the center is to find new ways to use old products. A workshop is used to repair discarded electrical appliances (which are then sold to earn the center money or donated to poorer countries such as Estonia). One of the most popular products made by the center is a fish-smoking box, which is made out of the drums from old washing machines.

The changes in Vaasa since the mid-1980s have resulted in a near-sustainable waste-treatment system (Fujita, 1999). The original aim of reducing waste sent to a landfill site by 70% has been exceeded significantly. By 1997 over 90% of household waste was recycled or burned, with just 9.5% sent to the town's new, smaller landfill.

Each 1,000kg of household waste is now treated as follows:

- 450 kg processed into pellets and burnt in the local paper mill (producing 2,400 kWh energy and 45 kg of ashes for disposal)
- 450 kg treated at Stormossen biological plant (producing 200 kg of high-quality soil and 450 kWh of electricity from biogas)
- 50 kg ferrous metals for recycling
- 50 kg of waste for disposal

The Vaasa Project has shown that waste treatment can be much more sustainable than it is in most of the developed world (Fujita, 1999). The project was completed with little government financial support (only 20% of the cost). Although the Vaasa project was not directly designed

for C&D waste removal, it provides an excellent model to demonstrate the fundamental basis on which all waste minimization plans should be created.

2.3.2. Automobile Recycling Process

Automobiles are one of the most common means of transportation. Automobiles are also products, which hardly get recycled, and are often trashed, in junkyards to corrode. Recycling their parts can be one of the most efficient ways to reduce waste.

In Europe, auto manufacturers have been asked to investigate the possibility of recycling their cars to avoid waste (Bras, 1995). The dwindling landfill space in an overcrowded Europe has resulted in tough European legislation regarding the post-use stage of a product's life cycle, such as reusing and recycling. There is also interest in the United States by GM, Ford, and Chrysler, which have formed the Vehicle Recycling Partnership, to research vehicle dismantling, and the American Automotive Manufacturers Association has come out with definitions regarding recycling.

The following outline illustrates various categories into which automobile parts can be recycled to become more useful (Bras, 1995).

1. **Recyclable - infrastructure and technology clearly defined** - Parts that are completely recyclable (or reusable), infrastructure clearly defined and functioning (e.g., body sheet metal, engine blocks).
2. **Potentially recyclable, but no infrastructure is available** – Parts that can be recycled but are not universal (e.g., plastic interior trim).
3. **Potentially recyclable, but process or material development is required** - Technology has not been commercialized (e.g., glass-fiber recycling).
4. **Energy recovery potential** - Known technology/capacity to produce energy with economic value (e.g., pyrolysis of tires).
5. **No potential for recycling known** – Technology of products that cannot be recycled (e.g., leather trim).

The European Commission is also working on similar recycling legislation for the auto manufacturers (Bras, 1995). The specific objectives are:

- Avoidance of waste,
- Reduction of landfill demand, and
- Reduction of toxicity.

In addition, the following limits are set on the maximum allowable percentage of a car that can be land filled (Bras, 1995):

- Beginning in 2002, a maximum of 15% of car weight can be land filled or incinerated without energy recovery.
- For new models beginning in 2002, a maximum of 10% of the automobile's weight can be disposed of in a landfill.
- A maximum of 5% of car weight disposal in 2015.

Automobiles are an example of the advancement in technology of recycling. Many automobile parts are not only created with a complex design, but also with materials that are difficult to recycle. This advancement in recycling technology exemplifies how advanced recycling has become, and will likely provide ideas for applications on construction and demolition materials.

2.3.3. Recycling Technology in New York City

Star Recycling, Inc., of Brooklyn, N.Y., is a C&D recycling center that demonstrates that with changing times comes the need to upgrade a facility (Brickner, 1999). Since it opened in the early 1990s, the company has made many upgrades to the machinery at the site. These machines have enabled different items to be processed. Examples of these machines include a water tank that allowed wood residuals to float for separation, a wood pellet-making machine, and different sorters and filterers. Star handles concrete, rock, ferrous metals (iron alloys), non-ferrous metals, wood, and dirt, and currently diverts about 60 to 65 percent of those as marketable items for commercial use. The facility

runs 5 1/2 days per week, with two ten-hour shifts each day, and processes more than 300 cubic yards of waste per hour.

2.4. Government Policy Regarding C&D Recycling

In some cities, government policies are in place to enforce recycling of construction and demolition waste. However, different policies are working for different communities. Because of this, it is hard to say what exact policies will solve construction and demolition problems.

In the state of California, State Assembly Bill 939 put forth a mandate stating that 50 percent of all waste was to be diverted to recycling by the year 2000 (Hackney, 2000). Additionally, the mayor of Los Angeles has put forth a goal of 70 percent recycling by the year 2020. According to the author, having these goals set has enabled the city to come up with better ideas for recycling. For instance, the recycling program is currently done in single-stream fashion, a technique in which all recyclable materials are put into one container for collection and are then sorted by machines at a processing plant. Since the switchover to single-stream, recycling has improved by 150 percent. Also, total savings to the city have amounted to over $20 million dollars so far and should continue to increase with each passing year.

Much effort is being made in and around Los Angeles, a city of 450 square miles and 720,000 households, to help with C&D recycling effort (Hackney, 2000). In order to increase C&D recycling, the Los Angeles Department of Works requires that all contractors erecting buildings for the city submit a report of plans for recycling efforts before the

construction can start (Ingalls, 2000). The city is also utilizing an outreach and education program, where pamphlets are given to public and private contractors informing them of what the benefits of C&D recycling are and what paperwork is necessary to perform construction jobs within the county. This outreach program is part of a large marketing campaign on recycling developed by the city (Hackney, 2000). The campaign includes television, radio, and print advertisements, a Customer Service Guide, a school outreach program, and random garbage checks by a recycling task force. However, it is difficult for Los Angeles to keep good track of how well the program is working because it is only required for those buildings being controlled by the county government (Ingalls, 2000). Private contractors are only sending in the reports on a voluntary basis.

In addition to recommending C&D recycling, the city of Los Angeles enforces tipping fees at its landfills. The tipping fees range from $5 to $35 per ton for C&D material (Block and Harrington, 2000). According to Block and Harrington, these fees are forcing contractors to look at the recycling education pamphlets and discover ways of recycling the materials that they are left with after demolition and construction work. One example was the building of the Los Angeles Police Department's Emergency Vehicles Operations Center, from which the contractor was able to recycle more than 13,000 tons of material from the project. The contractor was able to use the educational pamphlets to learn what materials were recyclable and where the items could be taken for recycling.

Beyond improving its recycling program, the city of Los Angeles is also leading by example. The city governmental departments are required to buy recycled material whenever possible and must buy only recycled paper when making paper purchases (Hackney, 2000). Los Angeles is also working on legislation to encourage private companies, such as the Coca-Cola Company, to use more recycled material in their products.

Another example of a city with an enormous recycling problem is the City of New York. New York City is one of the most densely populated cities in the world, and Grogan (2000) felt that there were no worse cases of garbage and waste than the situation there. He stated that New York City should be used by other nations and cities of the world as a case study of why recycling should be performed.

In New York City, Local Law 19 requires 25% of waste recycling for all of municipal solid waste (Corey, personal communication, 2001). According to Corey, although the recycling program used to be quite thorough, politicians have been able to define waste as they see fit in order to meet this requirement. In redefining waste recycling, former Mayor Giuliani included C&D waste in New York City's municipal solid waste stream. The city treats this waste the same as its other waste. Private companies remove all of the city's waste, which is taken to processing centers that reside in poor neighborhoods within New York City's borders, including South Bronx, Williamsburg, Redhook and Greenpoint in Brooklyn. Once the waste reaches these transfer stations, the private companies decide where it will go. In other words, New York

City has no say in what happens to it, whether it be recycled or put into landfills in other parts of the country.

Unfortunately, as Corey (2001) states, New York City can fall into trouble. The recent attack on the World Trade Center has provided an example of this. The last landfill within New York City, Fresh Kills, closed in March of 2001. However, because there was no other place to take it, all of the rubble from the 11 September attack has been taken there. The waste, spread out across parts of the 2500-acre site, is being gone through by members of the police force and is considered part of a crime scene (Schoofs, 2001).

2.5. Markets for C&D Recycled Material

Construction and demolition produce many waste products that can be recycled and reused. For example, dry wall is a principal wall material used for interior applications (CIWMB, 2001). It is made of a sheet of gypsum covered on both sides with a paper facing and a paperboard backing. The majority of drywall waste is produced by new construction, as drywall comes in standard sizes and must be cut to fit a specific wall. Therefore, constructing standard-size walls and flat ceilings can reduce drywall waste. Furthermore, if drywall is being used on a nonstandard size wall, custom-sized sheets should be ordered.

When drywall is placed in a landfill, it may produce hydrogen sulfide gas, particularly in wet climates (CIWMB, 2001). Hydrogen sulfide gas is toxic at high levels and has a foul, rotten-egg smell. Another method of disposing of drywall is incineration, which unfortunately produces toxic sulfur dioxide gas. As an alternative,

drywall gypsum can be recycled back into new drywall if most of the paper is removed. The recycled gypsum cannot contain a large quantity of paper in it because it reduces its fire rating. Drywall can also be recycled into soil amendment. The use of drywall for agricultural purposes, though, is still controversial due to other chemical components in drywall. Despite the controversy, gypsum does benefit soil because it improves water penetration and workability of soil. It also softens soil with high liquid content, helps neutralize soil acidity, and adds the necessary plant nutrients calcium and sulfur. Drywall usually contains boron as well, which acts as a fire retardant. Boron is a plant nutrient and its addition to soil with low boron content can be beneficial. Unfortunately, too much boron can be toxic to plants, and thus drywall must be used carefully as a soil additive.

A potential market for drywall waste are cement production (CIWMB, 2001). Gypsum can be added to cement to control its setting time. Unfortunately, high concentrations of paper cause problems and thus cement production companies are only interested in recycled gypsum with one percent or less paper content. Gypsum is also used in flea powder, where it makes up 90 percent of the inert material. Other proposed uses of gypsum are for use in water treatment, manure treatment, and animal bedding.

Another element of the construction waste stream is wood waste (CIWMB, 2001). The primary components of wood waste are lumber, trim, shipping pallets, trees, branches, and other wood debris from construction and demolition activities. The disadvantage of putting wood in landfills is that it takes up a large amount of space. Alternatives

for wood waste are to use it as feedstock for engineered woods, landscape mulch, soil conditioner, animal bedding, compost additive, sewage sludge bulking medium, and boiler fuel. All these uses for wood waste have the same requirements in that the wood must be separated from other wastes, cleaned by removing contaminants and fasteners, and ground or chipped. The ideal use of wood waste for construction and demolition activities is to reuse the structural elements, such as banisters, mouldings, and casings. However, if lumber is to be reused as a structural element, it needs to be recertified.

One non-profit company in the Los Angeles area is helping with C&D efforts in a new way (DeWeese, 2000). The Reuse People, Inc. is based in San Leandro, California, and is reusing C&D waste by taking it across the border to Mexico in order to aid Tijuana citizens in building houses. The company started in 1993 collecting donations from California contractors. In 1995, the company applied and received its contractor's license. Now able to perform construction and demolition work, the company helps on construction sites by sorting the waste and preparing not only for delivery to Tijuana, but also for recycling of the items that cannot make it there.

2.6. Public Acceptance of C&D Management

Public education is a key part to the success of a recycling program. The government cannot monitor everyone to ensure that everything that could be recycled is being recycled. Thus, the public's view of recycling is important (Chan, 1998). A survey done by Hong Kong's Environmental Campaign Committee in 1993 found that 98

percent of those surveyed believed that individuals have a responsibility to protect the environment. However, when those surveyed were asked if they actually practiced environmental protective behaviors, such as separating aluminum cans for recycling and adopting ways to reduce waste, the percentage of positive responses dropped to 60 percent. The results show that there is a discrepancy between what people believe should be done and their actual behavior. Seeing that a person's behavior does not always coincide with his/her attitude, some have gone as far as to claim that the ecological crisis is not a technical problem but rather a crisis of maladaptive behavior, and that the root of environmental problems is human behavior. Thus, no matter how many laws are passed or how efficient the technology is, if people do not feel obligated to practice environmentally conscious behavior, then the laws will not be obeyed, and the technology will not be used to its potential.

To encourage environmentally responsible behavior one must identify the factors that influence pro-environmental behaviors (Chan, 1998). One such factor is mass media. Television, newspapers, magazines, and radio are all useful means by which to educate the public on why they should behave in an environmentally conscious way. Mass media can also educate the public on what they can do to reduce waste and increase recycling. Another factor in encouraging pro-environmental behavior is social pressure. If a person's family members and friends are very environmentally conscious, then they are more likely to have more responsible environmental behavior than those with friends and family who are neutral towards environmental issues.

2.7. Current Situation in Hong Kong

Hong Kong is facing a challenging problem in that its landfill space is severely limited. It is projected that if nothing is done to reduce the amount of waste entering Hong Kong's landfills, the landfills will be exhausted between 2006 and 2008 (Environment and Food Bureau, 2001). The reason that Hong Kong's landfill life is being exhausted so quickly is due to the amount of C&D materials being disposed of there. C&D wastes makes up 38% of the overall amount of waste disposed of in Hong Kong's landfills each day. Over 38,080 tons of C&D materials have been extracted from construction sites each day (EPD, 1998). Of those materials, 6,300 tons of C&D materials are considered waste and are sent to the landfills. Each year, the waste piles up to over 2 million tons of C&D waste.

If nothing is done to increase the life of Hong Kong's current landfills, then Hong Kong will have to allocate around 860 hectares of new land on which to build new landfills. In response to the problem with Hong Kong's ever decreasing landfill space the Waste Reduction Frame Work Plan was developed in 1998 (WRFP, 1998). The purpose of the plan is to act as a guide to change Hong Kong's wasteful habits.

The Waste Reduction Framework Plan (WRFP) is responsible for creating dynamic and environmentally responsible programs to extend the life of Hong Kong's strategic landfills (WRFP, 1998). The goals of the WRFP are to minimize the amount of waste produced, to help conserve the earth's non-renewable resources, to increase waste recycling, to identify the true costs of waste management so that efficiency can be

maximized and the costs of collection, treatment and disposal of wastes minimized as well as to improve the institutional arrangements. The WRFP set a target to have 58% of Hong Kong's generated municipal solid waste and 84% of construction and demolition waste be diverted away from landfills by 2007. If this goal is met, it is estimated that the life of Hong Kong's strategic landfills will be prolonged from 2015 to 2019. In order to achieve this target, emphasis on collecting and transporting waste must be shifted to prevention and reuse of waste materials.

The WRFP is divided into three main program areas: the Prevention of Waste Program, the Institutional Program, and the Waste Bulk Reduction Program (WRFP, 1998). The Prevention of Waste Program's goal is to reduce the amount of waste being disposed of at landfills. The program also wants to increase the amount of waste that is recovered, recycled, and reused. For C&D waste, the strategy is to divert most of the waste to public filling areas and reclamation projects instead of landfills. In addition, more emphasis will be placed on on-site sorting and introducing a landfill-charging scheme. Long-term goals for C&D waste are to reduce its generation and to recycle and reuse as much of it as possible.

The Institutional Program involves setting up a Waste Reduction Committee (WRFP, 1998). Furthermore, this program calls for task forces to be set up within the various sectors of the community. The job of the task forces is to coordinate waste reduction activities, prepare legislative measures to make some waste reduction practices required and explore new ways to improve waste collection, transport, disposal, and management. It is the job of the Waste Reduction Committee to

oversee the progress of these task forces. In addition, the Institutional Program includes the removal of the institutional division between waste collection and waste disposal. The Bulk Reduction program is designed to explore waste-to-energy incinerators and composting plants as another means to solve Hong Kong's waste problem.

The Waste Reduction Committee (WRC) has a specific task force to focus on the C&D situation in Hong Kong (WRFP, 1998). It is the job of the C&D task force to make sure the targets laid out by the WRFP are met. One of the specific targets in the Waste Reduction Framework Plan is to reduce the amount of C&D waste entering landfills by an additional 20%. The expected amount of C&D waste to be generated over the next 10 years is 30,000 tonnes per day. Since most of the C&D waste is comprised of inert materials, much of the C&D waste can be used as public fill.

In 1994, only 35% of C&D material was delivered to public filling areas. This means that more than 15,000 tons of C&D material was disposed of in landfills per day (WRFP, 1998). However, thanks to the gradual implementation of the C&D management strategy, in 1998 80% of C&D materials were being diverted to public filling areas. Further reduction of the amount of C&D waste entering landfills can be achieved, as stated in the WRFP, by introducing a landfill-charging scheme, emphasizing on-site/off-site sorting of C&D material, implementing reuse and recycling of C&D material, and avoiding and minimizing C&D material through better design and construction management. It is noted in the WRFP, however, that even if these measures are effectively

implemented, the life of Hong Kong's strategic landfills will only be prolonged by six months.

To ensure that the measures stated above are effectively followed, the Waste Reduction Committee is implementing the following strategy (WRFP, 1998).

- Provide an adequate number of conveniently located barging points from where the public fill can be taken to reclamation projects;
- Impose charges on C&D waste disposed of in landfills;
- Provide on-site sorting facilities for future public demolition contracts;
- Encourage on-site sorting facilities in private construction sites;
- Provide off-site sorting facilities to separate mixed material. The inert material will then be used as public fill and any organic decomposable waste will be taken into the main waste disposal stream;
- Develop guidelines and codes of practice to reduce C&D material generation;
- Recycle as much material as possible for use in less demanding construction work, for example, as aggregate;
- Minimize the use of imported marine sand or other fill for reclamation projects; and
- Identify new outlets for the material, such as restoring old quarries.

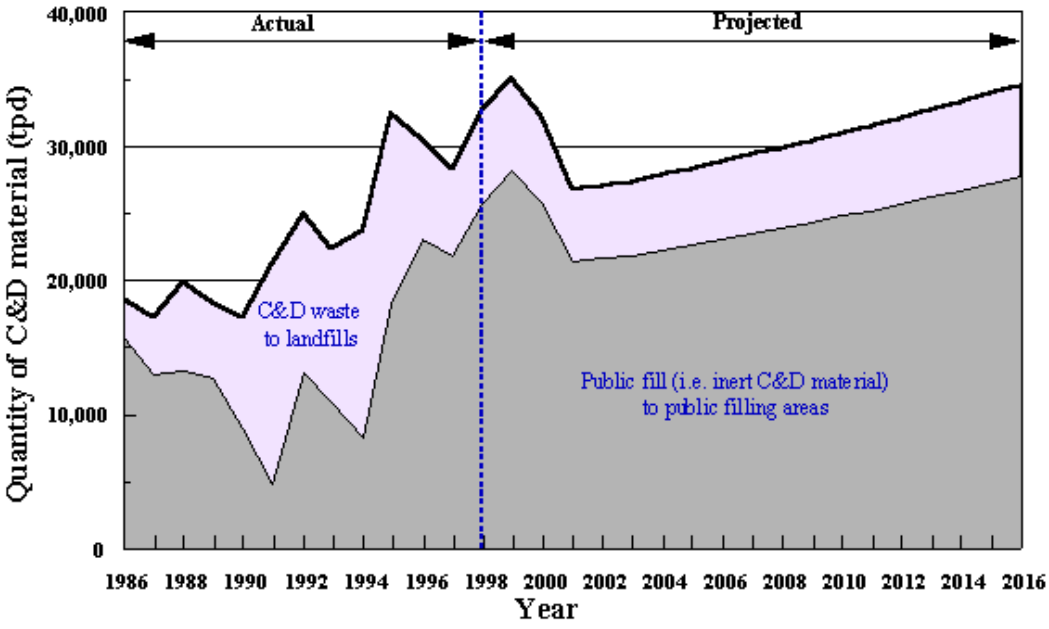
Hong Kong's long term C&D situation still faces serious problems. 80% of C&D waste is public fill, which is suitable for land formation (Legislative Council, 1999). Currently there are sufficient reclamation or site formation projects to accommodate the public fill Hong Kong produces every year until 2002 (Environment and Food Bureau, 2001). After 2002, though, it is uncertain whether Hong Kong will be able to find sufficient outlets for its public fill. In the 2000 review of the Waste Reduction Framework Plan, it is stated that there could be a potential swell in the amount of public fill generated (WRC, 2000). It is also stated in the 2000 review of the WRFP that there is currently a shortage of public fill capacity. If no outlets can be found for Hong Kong's public fill, it will most likely have to be disposed of in the landfills, which will result in the life of Hong Kong's landfills being severely decreased.

Unfortunately, it is not always possible each year to match the volume of public fill available and the demand for it (WRFP, 1998). If there were not enough demand for public fill, then any excess would have to be sent to landfills. If there were not enough public fill to meet the demand, then fill material would have to be imported, which is expensive and could cause environmental problems, since the fill would most likely come from a marine or land-based extraction project (Legislative Council, 1999).

Since 1998, the forecast of construction & demolition (C&D) material has been carried out by the Civil Engineering Department (CED), which oversees the management of public fill (i.e., inert C&D materials) through its Fill Management Committee (EPD, 1998). The public fill planning model, one of the key elements of the public filling

strategy set out by the Committee, has been developed by CED. The planning model, amongst other things, forecasts the quantity of C&D material will rise. Based on the information generated from the planning model, the forecast quantities of C&D material arising in 2001, 2006, 2011, and 2016 are provided in Figure 2.1. The forecast quantities of C&D waste to be disposed of at landfills are based on the current situation in which about 80% of the total C&D waste material is being diverted to public filling areas. The actual quantities of public fill and C&D waste disposed of at public filling areas and landfills respectively since 1986 are also tabulated in Figure 2.1.

One tool that can be used to reduce the amount of waste being disposed of in landfills and to improve a city's general environment is to implement charging schemes. Two general charging schemes may be implemented, where one is a polluter pays scheme, and the other is a user pays scheme (WRFP, 1998). A polluter pays scheme requires that those who cause pollution pay for the cost of treatment or clean up. As a result, a polluter pays scheme encourages waste producers to reduce their pollution in order to reduce their costs. A user pays scheme requires the users of waste disposal facilities or services to pay for the cost of using them. Implementing these charging schemes has been discussed for some time in Hong Kong. However, Hong Kong has failed to put them in place. As a result, taxpayer's money is being spent to cover the costs of waste disposal and environmental clean up. In addition, more land and facilities are being set aside for dealing with waste and clean up.



Year	C&D waste to landfills		Public fill to Public Filling Areas		Total C&D material
	Quantity (tpd)	% of total C&D material	Quantity (tpd)	% of total C&D material	Quantity (tpd)
1986	2,850	15.3	15,780	84.7	18,630
1987	4,220	24.4	13,070	75.6	17,290
1988	6,520	32.9	13,320	67.1	19,840
1989	5,580	30.3	12,820	69.7	18,410
1990	8,450	48.7	8,900	51.3	17,350
1991	16,380	77.0	4,880	23.0	21,260
1992	11,960	47.6	13,170	52.4	25,130
1993	11,520	51.4	10,880	48.6	22,400
1994	15,480	64.9	8,370	35.1	23,850
1995	14,120	43.6	18,280	56.4	32,400
1996	7,520	24.6	22,990	75.4	30,510
1997	6,480	22.8	21,950	77.2	28,430
1998	7,030	21.5	25,680	78.5	32,710
2001 (1)	5,360	20.0	21,460	80.0	26,820
2006 (1)	5,770	20.0	23,080	80.0	28,850
2011 (1)	6,310	20.0	25,220	80.0	31,530
2016 (1)	6,930	20.0	27,730	80.0	34,660

Remark : Figures on waste quantities are rounded off to the nearest 10 tpd and may not add up to total due to rounding-off.

Notes :

(1) Forecast figures on total C&D material are provided by the Civil Engineering Department.

Figure 2.1. Quantity of construction and demolition material (Poon, 2001)

2.8. Summary

This literature review has provided the necessary background information for a better understanding of this project. Construction and demolition waste management has many players, including politicians who have written legislative policies and companies that are utilizing C&D technologies as their business. In addition, advances in technology provide many ways for this waste to be handled.

Chapter 3. Methodology

Using the information gained from the Literature Review, a set of procedures for critically reviewing C&D waste management in Hong Kong was employed. For this project, interviews were set up with members of the Environmental Protection Department, professors in C&D management, managers of construction companies, workers for construction companies, members of Hong Kong green groups, civil engineers, Hong Kong architects, and members of the Hong Kong Housing Authority. The team analyzed information gained from interviews and government documents. Finally, the team observed construction sites, waste transfer centers, and landfills in Hong Kong.

3.1. Interviews

Interviews provided a medium to discover information first-hand from people involved with construction and demolition waste management. For this project, the team chose different types of people to get a balanced amount of information on C&D management in Hong Kong. Table 3.1 provides a summary of the groups of people chosen, the number of people in each group interviewed, and the reason for choosing them.

Table 3.1: Interview groups and reason(s) for choosing them

Group of interviewees	Reason for choosing them
Members of the Environmental Protection Department (3)	Provide information on government policy, programs in place and planned, and legislation in action.
Professors in C&D management (3)	Provide educational information on C&D research.
Managers of construction companies (2)	Provide company plans for waste disposal and demolition methods.
Workers for construction companies (2)	Provide information as to how well C&D recycling is being done by the company.
Members of Hong Kong green groups (2)	Provide information on who is performing C&D recycling and how well it is working.
Civil Engineers (2)	Responsible for design and operation of C&D facilities.
Hong Kong architects (1)	Provide information on plans in action before a building is even built with regard to C&D recycling.
Members of the Hong Kong Housing Authority (1)	Provide details on what techniques the government is using in construction of public housing.

Each of the interviews, whether with a member of the Hong Kong government or a construction employee, included the person to be interviewed and two members of the project team. One of the members of the project team asked the questions while the other concentrated on taking notes of the interview. The questions for the interviews varied among the different groups, with different follow-up questions emerging for each interviewee. See Appendix D for sample questions used for the groups. Analysis of the interview answers is covered in Section 3.3. All interviews included open-ended questions, and all interviewees remained

anonymous to maintain confidentiality. With these similarities understood, the distinctions for each group can now be presented.

Interviews with members of the Hong Kong government, including members of the Environmental Protection Department, were arranged with help from the Civic Exchange. The team traveled to these government agencies' locations for the interviews, and these interviews lasted from one to two hours each.

Professors in the field of Civil and Environmental Engineering (specifically C&D waste management) who reside in Hong Kong were contacted to schedule interview times, as were members of green groups, the C&D recycling industry, the construction industry, and the architect community. Each of these interviews lasted from one to two hours, depending on the answers provided and the follow-up questions asked.

With the combined information gained from the interviews, analysis of the answers provided was necessary to gain insight into what was happening with C&D waste in Hong Kong.

3.2. Direct Observation

The team performed direct observation of construction sites, public filling areas, and landfills in order to get a full understanding of what was happening with C&D waste in Hong Kong. Observation of eight different sites was performed, including the South-eastern New Territories (SENT) and Western New Territories (WENT) landfills, Tseung Kwan O and Kai Tak sorting facilities and public fills, the Island West Transfer Station, and the Furama Hotel, 31 Wyndham St., and 69 Wyndham St. construction areas.

Observation of construction sites showed how construction companies handle their waste. This provided insight into the actual behavior of these companies and revealed the degree of effectiveness of government policies. For this observation, the project team spent time at construction sites, watching where waste materials were stored and transferred. Other procedures monitored included the sorting of waste and practicing the use of common work areas such as for woodcutting.

By observing public filling areas, the project team discovered how construction and demolition waste was sorted and for what the filling material was used. Finally, landfills were visited to gain insight into how these sites handle waste brought from construction and demolition sites. Observations were made to determine if there was an attempt to separate the different wastes, or if there was a placement strategy in order to facilitate the best biodegradation of the material (C&D waste within landfills is used as a cover over municipal waste and can help in the breakdown of the material it conceals). A schedule of these observations is shown in Table 3.2.

Table 3.2: Schedule of direct observation visits

Location	Date	Length of time	Type of facility
Kai Tak	14-Jan-2002	30 mins.	C&D public fill
Island West Transfer Station	14-Jan-2002	1.5 hours	Municipal waste transfer station
SENT	14-Jan-2002	1 hour	Landfill
Tseung Kwan O	14-Jan-2002	30 mins.	C&D public fill
WENT	04-Feb-2002	1 hour	Landfill
69 Wyndham St.	07-Feb-2002 20-Feb-2002	30 mins. 30 mins.	Road and sewage construction site
31 Wyndham St.	18-Feb-2002 21-Feb-2002	15 mins. 15 mins.	Building construction site
Furama Hotel	19-Feb-2002 21-Feb-2002	1 hour 30 mins.	Building construction site

3.3. Analysis

In order to organize the large amount of information that the project team gathered from interviews and government documents, the following analysis techniques were employed. Interviews were processed based on interviewee's responses to the different questions. The responses were grouped into different coding themes based on the project team's interpretation of the interviewees' answers. These themes are listed below:

- Necessity of tipping fees
- Reason to employ tipping fees
- Responsibility of paying tipping fees
- Necessity of C&D waste sorting
- Where C&D sorting should take place
- Status of C&D recycling technology in use
- Use of public fill material

The knowledge gained provided insight into how the different players within the demolition and construction waste management field felt it should be dealt with.

The government policies of Hong Kong concerning C&D waste management were comparatively analyzed against those of Taipei and New York City. The policies were coded by their clauses into the following theme categories based on their content.

- Tipping fee usage
- Reclamation work
- Waste minimization
- Incineration
- C&D waste sorting

Using the data gathered from interviews, the information determined from comparative policy analyses, and the practices observed at different sites, the team was able to develop a critical review of the current situation within the Hong Kong construction and demolition waste management industry. In the next chapter, the findings of this project are presented.

Chapter 4. Results and Discussion

In this chapter, the team presents its findings from the research in Hong Kong. Based on the information gathered, the data are divided into the following categories: construction site and waste handling processes, tipping fees, waste minimization, sorting, public fill, recycling, alternate waste handling methods, and communication. Each of these sections includes interviews, direct observations, and policy analysis results (where applicable) and a discussion section on the topic. The discussion presented here provides all necessary information on which to make the conclusions presented in the next chapter and leads into the courses of action the team recommends. For a summary of the comparative analysis of the policies the team researched, please refer to the table in Appendix E.

4.1. Construction site and waste handling processes

In this section, the process by which a site is chosen for development and the flow of the waste the site creates are described. The information presented here was gathered from the many interviews and observations the team made throughout the project. The general process a site goes through starts with the leasing of land by a real estate developer. This piece of land, owned by the government, will have a plot ratio related to it. The plot ratio is a number that represents the total amount of floor space a structure built on it may have. For example, if the size of a plot of land is 500 m^2 and the plot ratio is 8, then the total amount of floor space the structure may have is 8 X 500 m^2 = 4000 m^2.

The next step the real estate developer must perform is the submission of an Environmental Impact Report (EIA). This report, which is submitted to the Environmental Protection Department, describes all of the ecological effects the project would have, including dust creation, noise production, and other concerns. This report must be approved before the real estate developer could choose a contractor for the project.

With the EIA accepted by the EPD, the real estate contractor is able to take tenders from different contractors to perform the job. For large projects, oftentimes a group of companies will come together to form a conglomerate to spread the cost of the project. Usually the conglomerate will consist of a construction company, a waste hauling company, and investment companies that hope to make profit from the project. In any case, companies submit their tenders, which include the cost of performing the project, and the real estate developer accepts one of the tenders for the project. The tender is then signed as a contract and construction (or demolition) begins.

The payment for the project either happens immediately after the completion of the project, or transpires in stages throughout the project development. This plan is laid out in the project contract and could be very important as to how much debt the construction company may incur from the project.

With the site development process understood, the course the demolition and construction waste takes can now be shown. For a full understanding of the situation, a site containing demolition *and* construction will be used. The first action that happens is the demolition

of the structure on the site. This is done with a wrecking ball to create a large heap of mixed waste, such as that shown in Figure 4.1. Some of this waste is sorted so that some of it can go to a public filling area. However, the rest of the mixed waste finds its way to a landfill. Approximately 40% of all waste that comes to landfills is from the construction and demolition industry.

Figure 4.1. Mixed C&D Waste

Very little waste produced by demolition is recyclable. With the completion of the demolition phase of a project, construction begins. During construction, lots of waste is still being generated, including packaging waste, cutoffs, scaffolding, and construction corrections. Packaging waste is material in which different construction products are shipped, such as paper wrap for a stack of timber. Some packaging waste

is recyclable, but most is made of cheap material that ends up in a landfill. Cutoffs are the material remaining after a piece of lumber is cut for use in a project. Cutoffs either could be reused on the site or could be recycled at chipping factories. Unfortunately, there are no wood-chipping plants in Hong Kong, so these items have to be delivered to a landfill. In Hong Kong, scaffolding mostly consists of bamboo. This creates a large amount of timber waste that adds to the amount of refuse taken to a landfill due to the lack of a wood-chipping plant. Construction corrections include material created by the tearing down of fresh construction due to errors or minor changes in building design. This material is usually sorted, as it is easy to do small sections of mixed waste at a time.

Other waste generated during the construction phase is excess material. Usually companies buy extra material, including floor and ceiling tiles, lumber, and concrete, just in case construction corrections occur and it is necessary to use more material than originally planned. Programs such as the FOE's tile collection program (discussed in Section 4.3.1) help the situation by reusing this excess material. Unfortunately, most of this excess material has been taken to landfills for disposal.

Each weeknight during the demolition and construction phases, a waste hauling company comes to the construction site to remove the trash generated that day. The reason the haulers come at night is so that they are not in the way of the construction activities taking place. The haulers are responsible for making sure the waste gets to the landfill (mixed C&D waste), the public filling area (inert sorted material), or to a municipal waste transfer station (packaging waste, timber).

4.2. Tipping fees

4.2.1. Interview results

According to the Hong Kong government, the purpose of tipping fees would be to provide a diversion method. In other words, because companies would have to pay to bring their waste to the landfill, more recycling and delivering to public fill areas would be done. This idea contradicts the misconception that the proposed fees are to make money for the government. Although "green" groups and most construction employees agreed that the tipping fees' main purpose would be for diversionary purposes, other construction workers felt that the government wanted to instill these fees simply to increase their income. It was believed that the government was already getting the money to cover the expenses toward the landfills via taxes on construction equipment and building supplies. A couple of interviewees felt that this was an important factor in that the government should consider altering the current tax structure to remove the landfill charges from taxation and impose direct tipping fees.

Figure 4.2 shows that many people believe that tipping fees are necessary in Hong Kong. All sixteen interviewees answered this question, so the n for the display is sixteen. 75% of those interviewed felt that these fees were necessary. The rest of those questioned said either they were not necessary or did not stress the necessity of these fees.

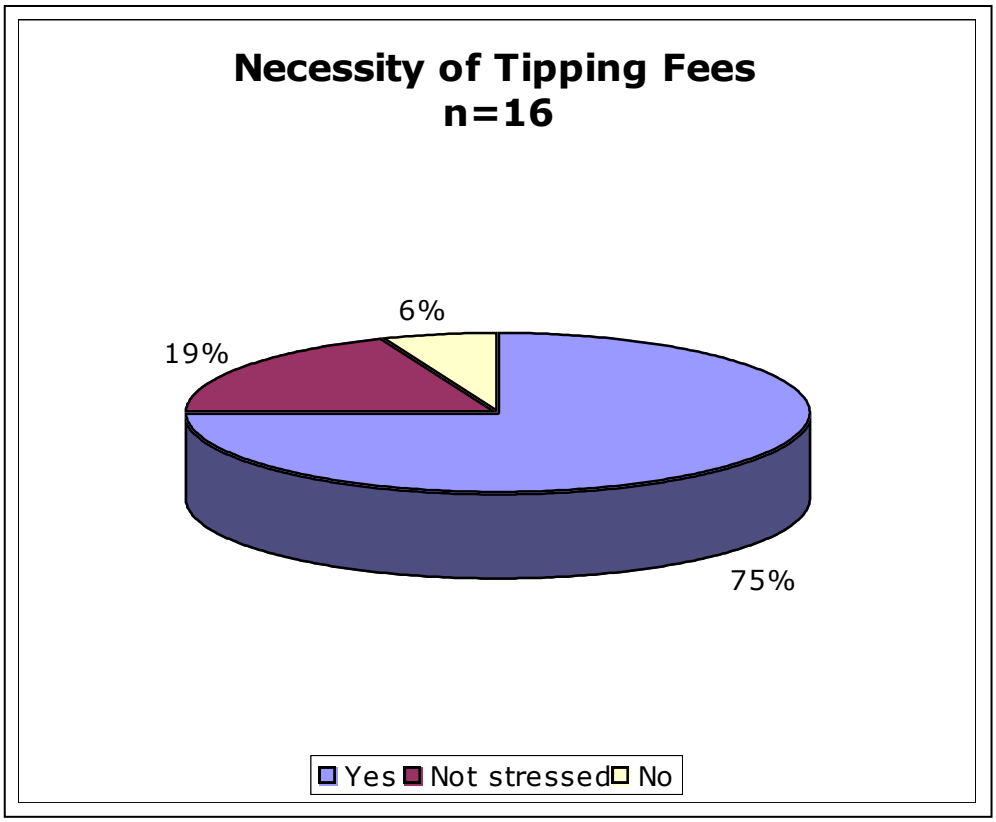


Figure 4.2. Interviewees' response to necessity of landfill tipping fees

People believe that tipping fees will help facilitate the diversion of construction and demolition waste from landfills. During interviews with the EPD, the team was informed that the plan being reviewed is for tipping fees of HK$125/tonne against C&D waste only (EPD, personal communication, 2002). The EPD went on to say that, if this plan were instituted, tipping fees would raise HK$400 million per year from all three landfills. The cost of running WENT landfill was HK$130 million/year, for SENT landfill HK$154 million/year, and for NENT landfill HK$113 million/year (EPD fact sheets, 2002). The total operating cost for the landfills was HK$397 million/year, so the HK$400 million/year from tipping fees would cover the cost of operating Hong Kong's three strategic landfills. Since the fees will only cover the cost of

the landfills, it is seen that these fees must be diversionary tactics, as no profit will be made.

If tipping fees were to be installed, the responsibility for paying them would have to be decided. A couple of people chose not to answer this question during the interviews, so n=14 for this item. According to our interviewees, the majority of those who specified a preference said that the construction companies should pay (see Figure 4.3). This follows the "the producer pays" idea, i.e., the person actually creating the waste is the one that pays for its disposal. This would cause mostly administrative problems because the trucks delivering the waste would have to be tracked back to the site from which they came. A further complication in this matter is that trucks may service many sites per day. Therefore, each time they bring waste to the landfill they might be delivering waste from a different site.

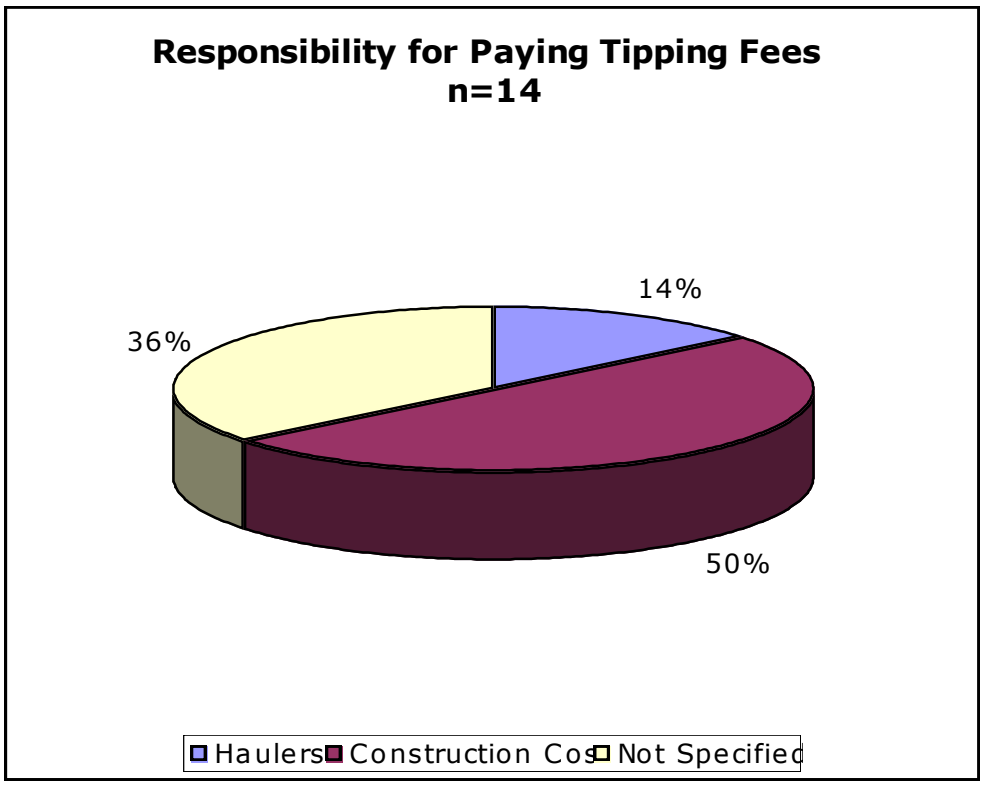


Figure 4.3. Interviewees' response to responsibility of tipping fees payment

4.2.2. Direct observation results

While visiting the Island West Transfer Station and both the SENT and WENT landfills, the team found that they already had weighing stations in use. These devices, as seen in Figure 4.4, allow the waste hauling trucks to be weighed before and after dumping their waste, thereby providing a net weight of the refuse they have been dropped off. This is useful in that if tipping fees were enacted the landfills would already have scales with which to weigh waste as it comes into the area.

Figure 4.4. Weigh station at IWTS

4.2.3. Discussion

Hong Kong at present has no tipping fees for its landfills. This is unique since most landfills throughout the world charge for dumping (EPD, personal communication, 2002). The result of this is that producers of C&D waste have no incentives to reduce or recycle the waste they generate. Due to the lack of incentives to reduce and recycle C&D waste, Hong Kong's landfills are becoming inundated with this material. In order to divert some of the waste coming to the landfills from construction sites, the government is proposing that tipping fees be imposed on construction and demolition waste that is brought there.

The idea of imposing tipping fees on landfills is not new for Hong Kong. Hong Kong has been trying since 1993 to enact tipping fees but has been unsuccessful in doing so (EPD, personal communication, 2002). Many people believe that landfill tipping fees would provide a greater incentive for producers of waste. However, it has been found that tipping fees have not been enacted due to much disagreement as to who should pay the fees and how they should be paid.

In the 1993 tipping fee plan, it was proposed that there would be different charges for different vehicles as they came into the landfill, and fees would be charged according to the size of the truck. In 1995, consultations took place with the different groups that would be involved, including developers, construction companies, and the waste haulers. At that time, the proposal indicated that the waste haulers would pay the tipping fee as they entered the landfill. The waste haulers objected to the fees for three reasons. The first was that the waste was

not theirs so why should they pay for it. The second was that they would not have the cash needed to cover the charge before being reimbursed by the construction company. Finally, the third was that the customer might go into debt on the project, and not be able to pay the haulers back for the fees. The government then decided that a different payment system would be necessary.

By 1996, the government's idea was to have different accounts for each hauling company. These would then be billed monthly. However, the haulers still objected, based on their first and third reasons given above. Around this time, the financial crisis of 1997 took place, so tipping fee discussions were delayed. In 1998, the EPD was searching for a way to make sure they had accounts for all the waste producers, but this has proven to be very difficult. They were, however, able to find the largest C&D waste producers. Combined, these companies contributed 80% of the demolition and construction waste that came to landfills. Currently, the idea is to charge only these largest waste producers at HK$125/tonne.

Based on the interview results, it appears that people within the construction and demolition waste management field are interested in these tipping fees being applied to C&D waste material. This provides a strong backing for tipping fee legislation.

4.3. Waste minimization

4.3.1. Interview results

From interviews with members of the Hong Kong government and the construction industry, it was found that Hong Kong is making some effort to reduce the amount of C&D waste that is generated. The Hong Kong Housing Authority has many specifications and guidelines for construction projects to reduce the amount of C&D waste they generate. Some of the items that the Housing Authority stress for building construction are pre-cast staircases, sprayed plaster, and prefabricated external elements. The Housing Authority makes a good effort of leading by example. All construction projects done by the Hong Kong Housing Authority are required to submit waste management plans outlining what measures will be taken to reduce waste generation and what will be done with any waste that is generated. It was noted, though, that the waste management plans are not always very helpful. Sometimes, waste management programs focus more on people responsible for the construction waste generated as opposed to what is actually going to be done to minimize the waste and what will be done with any waste generated.

From interviews with Hong Kong academics, it was found that excessive waste is generated in building construction due to over design. Over design is when, for example, a building is constructed with walls that are thicker than needed. Over design results in more materials needing to be removed when it comes time to tear down the building. A reason over design happens is because some building constructors

habitually choose to make their walls a standard thickness, and although their design is structurally sound, the walls in the building may be thicker than necessary.

It was also found from interviews with Hong Kong academics that computer software exists that can be used to reduce the amount of materials needed for building construction, resulting in less waste being generated. A company called TBCAD Technology Limited of the Hong Kong University of Science & Technology has a product called Tall Building Computer Aided Design (TBCAD), which can be used to streamline the building design process (TBCAD, 2002). The program offers a structural optimizer that can produce a cost-effective design. In TBCAD, a user is able to define the geometry of a building structure using standard floor plans and storey heights. The user can then run the program to see if any optimizations can be made to their building design. TBCAD can be used to see if the walls in the building design can be made thinner and still satisfy the standards of the building code. Besides producing less waste, an optimized building design with thinner walls is beneficial because it will save money on building material costs as well as produce more floor area.

From interviews with Hong Kong's green groups, it was learned that there exist some programs to help reduce C&D waste. Friends of the Earth, a green group in Hong Kong, has initiated a tile collection program to prevent excess tiles from being disposed of in landfills (FOE, 2002). Usually, a contractor orders an excess of two percent of tiles for a construction project. The reason for this is that there are usually tight deadlines in building construction, and if any tiles are lost or damaged,

the contractor cannot afford to wait for a new order of tiles to arrive. However, if the contractor is fortunate and no tiles were lost or damaged, then he will have an excess of tiles. Since the excess is only two percent, which is small in the eyes of the contractor, the tiles are disposed of in a landfill. Friends of the Earth takes the excess tiles from contractors and stores them in a warehouse, later giving the tiles to organizations that are in need of them for free. Such a program offers a very effective and beneficial way to reduce the amount of C&D waste entering landfills.

After talking with members of Hong Kong's Environmental Protection Department, it was found that they distribute a pamphlet entitled "Site Practice for Waste Reduction in the Construction Industry" which outlines basic techniques that can be implemented to avoid and reduce the amount of C&D waste generated by construction projects. In addition, the EPD distributes a VCD entitled "The New Era of Low Waste Construction," which describes construction techniques that generate less waste. The Environmental Protection Department also has a website dedicated to C&D information. The information that is presented in the different forms of media distributed by the EPD is very enlightening in updating people on how C&D waste can be avoided and minimized.

4.3.2. Policy analysis results

Hong Kong currently has several policies on waste minimization. The following is a basic breakdown of some of the current policies in place.

No. 29/00
Waste Management Plan
This Circular introduces the requirements that contracts must include the preparation and implementation of a waste management plan.

No. 243
Construction and Demolition
This Practice Note reminds readers of the need to consider waste generation and its management at the planning and design stage as well as at the construction stage of building development. The Waste Management Plan concept and the Trip Ticket System are introduced.

No. 245
Waste Minimization
This policy provides for the provisions of Fitments and Fittings in New Buildings (Poon, 2001).

A Working Group (WG) comprising of government officials and representatives of the building industry has studied the issue of the provision of sanitary fitments in new buildings. The WG has recommended that modifications of the relevant building regulations be considered so as not to require certain sanitary fitments to be installed at the time of issuing an occupation permit. Individual cases were to be judged on their merits.

No. 19/99
Metallic Site Hoardings and Signboards
This Circular establishes a policy requiring the use of metallic site hoardings and signboards in order to reduce the quantity of timber used on construction sites (Poon, 2001).

In comparing Hong Kong's policies with those of New York City, it was found that New York City deals with waste minimization in a similar manner. New York City requires that construction plans include a waste management plan during the bidding process. This allows for evaluation of each bidder based on how they would approach the management of waste before any waste is generated or removed.

4.3.3. Discussion

It has been found from interviews that current construction and demolition methods implemented in Hong Kong produce excessive waste. One reason for this is Hong Kong's general waste management strategy. Hong Kong is currently transitioning from a pollution control to a waste reduction strategy. A pollution control strategy is the traditional approach to a waste management plan where waste is collected and treated or disposed of (Wong, 2000). A waste reduction strategy is different in that the goal is to generate no waste at all. Hong Kong is adopting a reduction strategy because it is quickly running out of landfill space and thus needs to make every effort to reduce the amount of C&D waste generated.

Improper planning from the start of a construction project can result in excessive C&D waste being generated. It is tempting, when deadlines and budgets are tight, for building constructors to use cheap, low quality materials in their building designs. Use of low quality materials results in excessive waste generation during construction due to the materials being easily damaged. In addition, a building constructed with low quality materials will require more maintenance throughout its lifetime, which will in turn generate more waste. Also, such a building will most likely have a shorter life expectancy. Another large waste producer is dimensional dis-coordination, which means that the dimensions in the building do not match the dimensions of the materials being used. Mismatches in dimensions require the materials to be cut to fit the building designs creating excessive off-cuts.

In addition to better planning in the design phase of the building process, special construction techniques can be implemented to reduce the amount of waste generated (Poon, 2001). The use of metal formworks is one construction technique that can be implemented to reduce waste during construction. Metal formwork offers several advantages over timber formwork, which is currently used quite often. The big advantage is that metal formwork can be used many times as opposed to timber formwork which can rarely be used a second time (Wong, 2000). Metal formwork also saves time and labor in erecting, striking, and re-erecting (Poon, 2001). The drawbacks of metal formwork are that it is expensive, and it is produced in standard sizes. Since metal formwork normally comes in standard sizes, getting it in a customized size or form is even more expensive, which is a problem for building designers who may find the standard sizes not aesthetically pleasing. Small companies shy away from metal formwork because they see it as too expensive (Wong, 2000). However, metal formwork makes up for its cost, since it can be used many times over.

The use of metal scaffolding is another way construction activities can reduce waste (Poon, 2001). It is a traditional practice in Hong Kong to use bamboo scaffolding in construction. After the construction project the bamboo is usually not suitable for reuse due to cracking and general strain over time. In addition, poor and inconsistent quality of bamboo itself has led to increasing reports of bamboo scaffolding related accidents. Metal scaffolding provides a more durable solution. It can be reused many times and is much safer. Unfortunately, it is more

expensive, but the fact that it can be reused many times makes up for its higher initial cost.

Yet another way to reduce construction waste is to use prefabrication (EPD, 2001). Prefabrication provides a more efficient way to construct buildings than concrete casting. Construction materials such as walls, floors, and staircases can be made in factories using high quality metal molds, which produce very little waste. Prefabrication provides for better quality building parts and reduces the amount of labor intensive work needed on site since they are manufactured in factories. The only real disadvantage to prefabrication is that it can be difficult to store prefabricated parts onsite.

The Hong Kong government has taken some initiative in spurring waste minimization by requiring contractors of all public works projects since 2001 to organize and apply Waste Management Plans (Environment and Food Bureau, 2001). The government hopes that by requiring Waste Management Plans contractors will become more conscious of how much waste they generate and will take solid steps to avoid and minimize their C&D waste. Furthermore, by having a Waste Management Plan a contractor can look ahead to see if there are any possibilities where he could reuse or recycle any of the generated waste. As an incentive, contractors who effectively implement their Waste Management Plan will have better chances in winning other public works contracts in the future.

Currently there are no requirements for the private sector to organize and apply Waste Management Plans (Environment and Food Bureau, 2001). The government is developing an assessment system to

review green and innovative buildings however. The assessment system would work by giving credits to building constructors who are implementing measures to minimize C&D materials. Examples of ways building constructors could earn credits are by using metal formwork, prefabrication construction, and/or modular design. In order to make the assessment system appealing to building constructors, the government would offer incentives such as fast-track plan processing. Public commendations would also be given to projects with high scores.

4.4. Sorting

4.4.1. Interview results

Based on the information gained from our interviews it was made clear that the majority of people believed that sorting was key to minimizing C&D waste and keeping it out of Hong Kong's three strategic landfills. The best place to do sorting would be on-site. However, many construction projects are in congested areas and thus have limited space. Because of the on-site space being very precious, there is little room available to do sorting. In response to this, many people believe that there is a significant need for off-site sorting facilities. Currently in Hong Kong, there are two sorting facilities. One is located in the South East New Territories landfill. The other facility is located in Tseung Kwan O. Both of these sorting facilities were observed and are discussed in the next section. The Tseung Kwan O facility has been a pilot study for sorting C&D waste, and the contract for the facility was reported to be ending this year.

4.4.2. Direct observation results

In order to get a good understanding of how much effort is made to sort C&D waste in Hong Kong some construction and demolition sites were directly observed. Specific construction sites that were observed were the 31 Wyndham Street and 69 Wyndham Street. A demolition site that was observed was the Furama Hotel. The Tseung Kwan O sorting facility was observed as well.

The Furama Hotel is a current demolition project in Hong Kong. The company responsible for the demolition was doing some selective demolition. It was observed that all the windows had been removed from the building and at the time of the observation, furniture and other fixtures were being removed as well.

At 69 Wyndham Street, road construction was observed. The site only produced one type of waste, that being road pavement waste, so there was not much need to do sorting. In addition, the site was fairly small so not much waste was generated daily. The waste produced from the road construction was left on the side of the road until nighttime, when it was picked up. One observation made was that there was trash mixed in with the site's C&D waste. The trash came from the workers as well as from passers by who saw the construction site as a place to leave litter.

Another construction site that was observed was 31 Wyndham Street. The site was observed to be in disarray as there was little if any attempt to sort the site's waste. The waste observed was in mixed piles scattered all over the place. As a result, on-site safety appeared to be

poor. The site was fairly tight with regards to space, and the mixed C&D materials took up a good portion of the space.

Another place that was observed was the C&D sorting facility in Tseung Kwan O. The sorting facility was a pilot study to gauge how successful C&D sorting would be. The contract for the facility runs out in 2002. The goal of the facility is to take mixed C&D waste and turn it into suitable material for public fill. To make the material suitable, contaminants such as metal, paper, and plastic must be separated, and the remaining items must be the correct size. The sorting facility is small but does a relatively good job at sorting mixed C&D waste. If the mixed material received at the sorting facility is too big to be used as public fill, it is crushed by a machine into a suitable size. The sorting machinery uses a trommel, which is a rotating cylinder that separates C&D waste material of different sizes. The sorting machinery also used a magnet to separate metal and a blower device to separate lightweight materials such as plastic, paper, and wood. It was observed, though, that there was still a considerable amount of wood, plastic, and metal mixed with the public fill. It was stated that the reason as to why there was a lot of metal mixed with the public fill was because a lot of metal in C&D waste is encased in concrete, which is too heavy for the magnet to separate.

In addition to the sorting facility at Tseung Kwan O, it was observed that at the South East New Territories (SENT) landfill a C&D waste sorting facility was setup to handle the mixed C&D waste that was received at the landfill. The waste was seen as very mixed and therefore hard to sort. Since the waste was being sent to a landfill, it appeared that little thought was given by the producer to separate any of the waste.

Some of the waste required sorting by hand, and given the amount of C&D waste, it would be quite overwhelming, if not impossible, for the landfill to do the hand-sorting. The landfill was able to make some reuse of the sorted C&D material. One place where it could be used is in landfill covering. At the end of every day, a layer of dirt was placed over the trash in the landfill to prevent the trash from possibly being blown away and to reduce odor. In general, the SENT landfill appeared to be operating quite efficiently.

4.4.3. Policy analysis results

Hong Kong currently has Policy No. 5/98, which promulgates that starting 1 April 1998, all demolition contracts must include a requirement for on-site sorting of all C&D material prior to disposal. A particular specification clause must be included in the tender documents for mandatory on-site sorting, processing, and disposal of C&D materials (Poon, 2001). This is a good step toward reducing the amount of C&D waste that enters landfills.

4.4.4. Discussion

Sorting is a key part to minimizing C&D waste. When C&D waste is disposed of in landfills, it is because it is mixed and therefore unsuitable to be used as public fill. Since the majority of C&D waste is generated from demolition (Koenig & Liu, 2000), the method by which a building is demolished affects how easy the demolition waste can be sorted (Poon, et al., 2001). There are several different methods of demolition commonly used: hammering, hitting, crushing, bursting, and

blasting (Poon, et al., 2001). Hammering is a top-down procedure where a building is broken down by machine-mounted or hand-held percussive breakers. This method allows for easy sorting of waste during demolition. Hitting involves using a crane and wrecking ball to smash-in a building. This method produces a lot of noise, dust, and vibration. In addition, waste is intermingled and therefore hard to separate. Crushing is another top-down approach where a building is broken down using jaw type or C-shaped crushers and results in easy sorting of waste. Another method, bursting, is the practice of using a chemical agent such as calcium oxide to induce tensile stresses to crack the building structure. This method allows for easy sorting of waste. The last method, blasting, is the use of explosives to destroy a building. This process results in a pile of mixed demolition waste that is very hard to sort. Thus, which demolition method a company uses will determine how worthwhile it is for the company to sort the waste. Since the bottom line for any company is cost, it is highly unlikely that a company using the method of blasting to demolish a building will invest any time or money in sorting the waste.

There is yet another method of demolition that is believed to be the most effective in sorting demolition wastes. The method is called 'selective demolition' (Poon, et al., 2001). This method requires that before and during the demolition process material of different categories be concisely sorted to prevent any contamination of inert or recyclable parts. Selective demolition is reverse construction in which the building is dismantled and demolished in roughly the opposite order in which it was constructed. Selective demolition usually follows the procedure of

first removing non-fixtures (Poon, et al., 2001). The second step is the removal of doors, windows, roof components, air conditioning, etc., leaving just the building structure remaining. For the third step the building structure is demolished. Using this technique, Poon estimated that the overall recovery weight of demolition material can be increased to 90% (Poon, et al., 2000). Although selective demolition offers an effective way to sort demolition waste, it is a very expensive and labor-intensive process. It has been estimated that the cost of selective demolition can be as much as 15 percent more than standard demolition methods.

4.5. Public fill

4.5.1. Interview results

It was found from interviewing people in the construction industry that public fill capacity is running low. Excessive public fill is disposed of in landfills. It was also learned that public fill is often superfluously contaminated. At times public fill can be contaminated with such things as wood, plastic, and metal. High concentrations of plastic and/or metal in public fill make it less desirable as fill because metal and plastic can have adverse effects on the environment. Wood in public fill can also be contaminated with such chemicals as pesticides to protect it from termites. Construction companies usually mix contaminated public fill with clean public fill to reduce the overall level of contamination. This method reduces the amount of environmental impact that public fill will have.

4.5.2. Direct observation results

To get a clear picture of what public fill is and for what it can be used, the public filling area in Kai Tak was observed. Public fill is stored at Kai Tak so that it is available for future projects that can make use of it. It was found that public fill is very suitable for reclamation projects. However, not all reclamation projects make use of the public fill. This is because the supply of public fill is not always enough to meet the needs of the reclamation project. Aside from reclamation, public fill can be used as fill for general construction and landscaping projects. Unfortunately, some materials stored at the public filling area were found to be unsuitable for reuse as they were still too contaminated. It was observed there was a large amount of asphalt waste material at Kai Kak, and there are currently no plans for its use.

4.5.3. Policy analysis results

Hong Kong currently has Polices No. 4/98 and No. 4/98A that describe correct and efficient use of public fill in reclamation and earth filling projects. Circulars based on these policies broadcast their information, which require reclamation and earth-filling projects with imported fill requirements of 300,000 m^3 or more to consider using public fill (Poon, 2001).

4.5.4. Discussion

Despite the fact that there are policies concerning public fill, some reclamation projects such as the Disney theme park project have not been making use of public fill. This is because public fill does not settle

as fast as ocean sand, and the supply of public fill fluctuates. Thus, reclamation projects with tight deadlines such as the Disney project opt for ocean sand over public fill.

In order to overcome the situation where public fill capacity is running low, the government is looking to establish temporary fill banks to stock pile the materials until new reclamation and earth filling projects are available for making use of public fill (Environment and Food Bureau, 2001). The Hong Kong government is planning to establish these temporary fill banks in Tseung Kwan O Area 137 and Tuen Mun Area 38. These sites were chosen because they are far away from residential and commercial development and have the capacity to stockpile approximately 16 million tons of materials between late 2002 and the end of 2005.

4.6. Recycling

4.6.1. Interview results

From interviews with members of Hong Kong's government and academics it was found that Hong Kong is currently conducting studies on the merits of using recycled C&D materials in construction projects. Currently, there are pilot studies on using C&D material as aggregate for road sub-base and road base pavement. In addition, there is research being done to see how effective it is to recycle C&D waste as aggregates for such applications as concrete paving blocks, ground paving, footpaths, benches, and stools. It is believed by some that with sufficient recycling facilities, the C&D waste stream could be significantly reduced.

One consistent point that was brought up in all interviews, though, was that recycled aggregates cost more than virgin materials.

The fact that recycled materials cost more makes it harder to persuade construction companies to use recycled materials. Unfortunately, the problem cannot be easily fixed by placing taxes on virgin materials. The supply of C&D materials to be used as aggregates for recycled products fluctuates. Some years, there is a large quantity of C&D waste that can be recycled. Other years there is very little. In times when the economy is good, there is usually a lot of demolition and construction, which inevitably results in higher levels of C&D waste being generated. At other times when the economy is bad, there is less development and therefore less waste. Placing a tax on virgin materials would definitely persuade construction companies to use recycled materials, but at times, when there is no C&D waste to recycle, having a tax on virgin materials would be unfair. Having a tax on virgin materials one year and then removing the tax another year would be undesirable as well.

It was brought up in an interview that Hong Kong's quarries will be running out within a couple of years. As a result, Hong Kong will have to import all of its virgin materials from the mainland. Importing virgin materials from the mainland will be an expensive process, and thus there might be a shift in interest for recycled materials in the coming years.

Another fact that was gained from interviews was that many countries recycle inert C&D waste material in road pavement. Australia and the United states are good example of countries that do this. Hong Kong is unique in that the relationship between the amount of inert C&D

material that can be recycled in road pavement and the amount of roads available to absorb the material is 5 to 1, whereas in most other areas the relationship is 1 to 5. Hong Kong simply does not have enough roads to absorb all of the C&D waste that is produced each year.

4.6.2. Policy analysis results

Hong Kong currently has Policy No. 31/00, which allows the use of suitable recycled inert construction and demolition materials in public works projects. Some constructors in Hong Kong are uncomfortable about the quality of recycled C&D materials. This policy makes it clear to those that are skeptical that the quality of recycled inert C&D materials is good enough to be used in construction projects.

4.6.3. Discussion

Currently in Hong Kong, there are no recycling facilities for C&D waste. The government is planning, however, to set up temporary recycling facilities at Kai Tak and Tuen Mun in late 2002/early 2003 (Environment and Food Bureau, 2001). It is important that the government pursue these facilities because recycling is extremely important. Aside from creating a more environmentally concerned image, recycling provides alternative outlets for C&D waste. Mixed C&D waste received at landfills would be excellent specimens to be taken to C&D waste recycling facilities to be used as recycled aggregates (Mattravers, 2000). Public fill is another suitable source for recycled aggregate; however, it is not a reliable one. Public fill is usually used in

reclamation projects, but at times when there is an excess of public fill material, that excess could be diverted to recycling facilities.

There are several benefits to using recycled C&D materials (Mattravers, 2000). One is that there could potentially be a dearth of virgin aggregate in the future, and by using recycled materials the possibility of this happening would be prolonged. Another benefit is that the recycled materials might be closer to construction areas, and thus this would save on costly hauling of virgin materials from more distant places such as Mainland China. It costs money to import material, and at the same time it costs money to landfill similar material. In addition, there are increasing environmental concerns and restrictions to quarrying and ocean dredging. An example of such a concern is in South China where numerous islands in the Pearl River Delta have been destroyed to satisfy local demand for virgin aggregate. Thus, the use of recycled C&D materials provides a more environmentally sound alternative than quarrying and ocean dredging.

Hard inert material from C&D can be recycled into aggregates for concrete and asphalt production (Environment and Food Bureau, 2000). These materials can also be turned into granular materials for use in road sub-base and drainage bedding layers. The quality of the C&D waste determines how suitable it is to recycle. If the waste, for example, is high grade concrete taken from a demolition site, and it is pure (not mixed with metal, wood, paper, etc.), then it is very suitable for recycling as concrete aggregate (Ilic, et al., 2000). On the other hand, if the concrete material from a demolition site is, for example, mixed with plastic or wood, then it will not be suitable as aggregate for concrete

production. In addition, most C&D waste requires processing before it can be recycled (Environment and Food Bureau, 2000). Processing usually involves crushing the C&D material so that it is a suitable size for use as aggregate (Law, 2000). The material is purified as much as possible by removing any contaminants. Such processing can be very costly and may result in recycled materials being more expensive than virgin materials. Although recycling C&D waste can be very expensive, a bigger problem for C&D recycling is the lack of demand for recycled products.

There are many reasons why there is a lack of demand for materials made from recycled C&D waste. One reason, as stated above, is that virgin materials are cheaper to use. Another reason is the variability of the material (Mattravers, 2000). The more effectively C&D waste is sorted, the better the quality of the recycled material. Unfortunately, C&D waste can be hard to sort, especially if it is coming from a demolition project. Thus, the quality of recycled materials cannot always be guaranteed. Most of the time, virgin material is of better quality than recycled material, but not always. The inability to ensure the quality of recycled materials results in developers and contractors being hesitant to use such materials. Another reason why construction companies are unwilling to use recycled materials is that virgin materials might be more accessible to them. Construction sites are not always located near recycling facilities (Dougherty, 2000). One other point to note is that even if Hong Kong currently had operational recycling facilities, and even if clients were willing to use recycled materials, the fact that there

are no landfill tipping fees provides little incentive for producers of C&D waste to take their waste to recycling facilities.

These reasons for the lack of demand for recycled products brings up the point that when it comes to recycling waste materials, the most difficult challenge is not designing efficient recycling facilities and collection systems, but rather developing a commercial value for the recovered waste (Dougherty, 2000). As stated before, recycled materials may be more expensive than virgin materials, and virgin materials usually are of better quality than recycled materials. An imbalance in the supply and demand for recycled materials can drive down the price for the materials and increase the cost of collecting and producing them. Since recycled C&D materials are usually a second choice to virgin materials, sellers of recycled C&D materials have no ability to affect the price of the materials. All sellers of recycled C&D materials can hope for is that they get a fair price from the customer.

When creating markets for recycled materials, one should note that traditional markets usually can not absorb the full volume of materials being recovered for recycling (Dougherty, 2000). What is meant by traditional markets is, for example, recycling glass bottles to be used in the production of new bottles, or recycling paper to be used in the making of new paper or recycling concrete as aggregate for new concrete. The reason traditional markets cannot absorb full volumes of recovered material is due to the lower quality of the recycled product. For example, recycled concrete is not usually suitable for use in building construction (Ilic, et al., 2000). Thus, alternative markets need to be sought. An example of an alternative market for concrete waste is aggregate for road

paving. Many countries have recycled concrete into their roads. Victoria, Australia, for one, recycles 750,000 tones of concrete each year into road pavements (Johnston, 2000). Thus, a more advanced recycling program will seek first to understand the intrinsic engineered value built into the material to be recycled, then it will build on the inherent characteristics of the material, and finally it will develop new applications that use and value the engineering characteristics of the material.

4.7. Alternate waste handling methods

4.7.1. Incinerators

4.7.1.1. INTERVIEW RESULTS

From the team's interviews, it was learned that incinerators are not extremely effective but are a method of waste removal. Incinerators are mostly used for municipal waste rather than C&D waste. However, using incinerators can reduce some C&D waste. C&D waste such as concrete cannot be reduced through an incinerator, but materials like timber can be reduced by such a method. Incinerators are alternative methods of reducing waste but should not be strongly relied on for C&D waste material. Waste minimization should be about reducing the waste produced, not trying to reduce the waste that continues to grow.

4.7.1.2. POLICY ANALYSIS RESULTS

Some chemical wastes are already incinerated at the Chemical Waste Treatment Center (CWTC). It is intended that clinical wastes will

also be disposed of at the CWTC starting from 2002. The government plans to develop incineration facilities for the disposal of municipal waste, clinical waste, sewage sludge from the sewage treatment plants, and animal carcasses. It is intended that these facilities will incorporate the highest possible environmental standards and emission controls. The government recognizes, however, that there are legitimate community concerns about emissions such as dioxins, and currently researching the feasibility of instituting the use of incineration.

4.7.1.3. DISCUSSION

Traditional aid-funded solutions for construction waste disposal in Asia have often been based on the export of western technology, either incineration or composting (Nair, 2002). In many cities the moisture content of the refuse is too high to burn without the addition of expensive support fuel. In addition, incinerator plants have extremely high capital cost and require skilled labor for both operation and maintenance. Given these drawbacks, the potential for incineration in Asia is limited in the near future. The only exception would be special situations such as that in Singapore, Hong Kong, and Taiwan and for specific applications such as for clinical wastes and other selected hazardous wastes. Taiwan currently has 21 incinerators, which are mostly maintained with the most modern technologies. The incinerators are much more efficient and cleaner than the incinerators used twenty years ago.

4.7.2. Waste Island off Lantau

4.7.2.1. INTERVIEW RESULTS

An artificial island to be used as a waste dump was proposed to be built off Lantau as a temporary landfill for wastes. The island proposed is to be made from public fill with the capacity of 700 hectares. Due to the fact that Hong Kong's landfills will be filled up between 2005 and 2015, a new landfill must be created for the waste. Figure 4.5 demonstrates the limited areas for possible landfill development in Hong Kong.

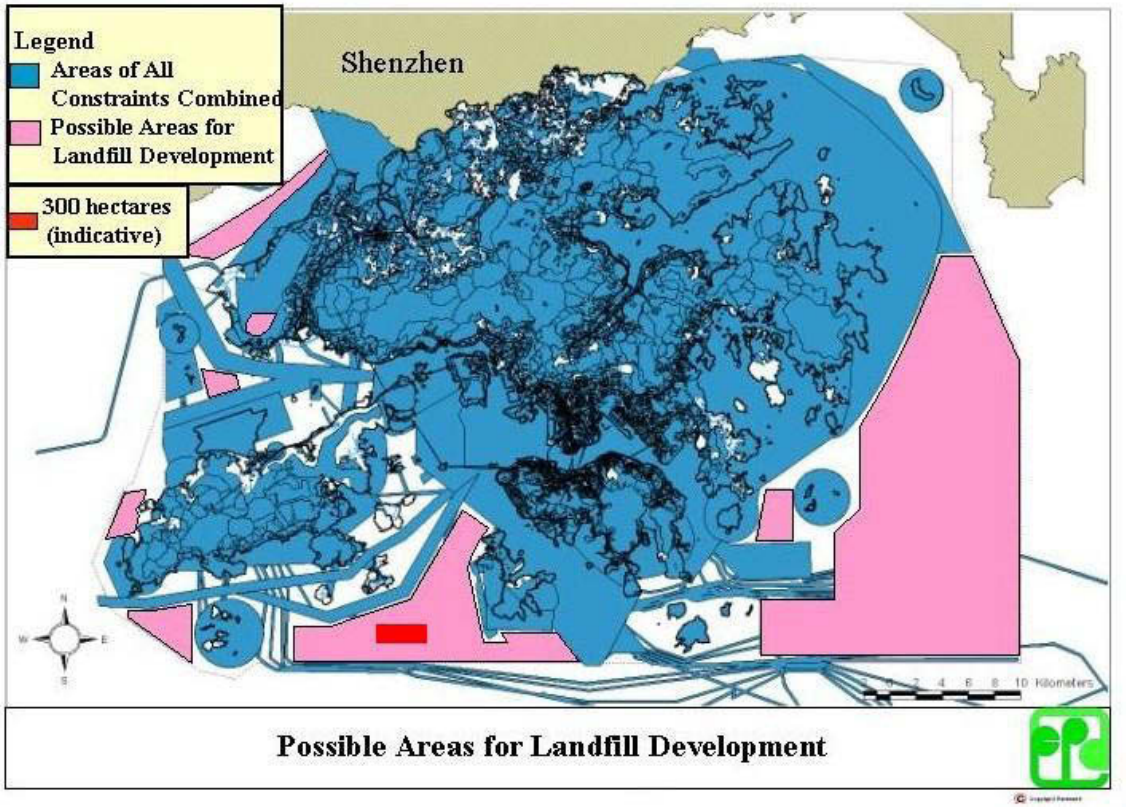


Figure 4.5. Possible Areas for Landfill Development in Hong Kong (EPD, 2001)

4.7.2.2. DISCUSSION

The waste island is only a temporary solution to the management of waste. The new island can only be made in the pink shaded area shown in Figure 4.5. If such reclamation projects continue, there will be no room in the Hong Kong Bay area. Such a project can be harmful to the ocean environment and can be very costly for construction and maintenance.

4.7.3. Exporting C&D waste

4.7.3.1. INTERVIEW RESULTS

C&D wastes do not have to be managed in the Hong Kong area. Exporting C&D waste to other countries or Mainland China, e.g., Guangdong Province, is an alternative method. However, exporting C&D waste can be very difficult and very expensive. While recycled materials may generate revenue, C&D waste can only be dumped in landfills. Many countries, such as Taiwan and Singapore, are not willing to take Hong Kong's waste because they do not have an over abundance of land themselves.

4.7.3.2. POLICY ANALYSIS RESULTS

Controls on the import and export of waste under Hong Kong's Waste Disposal Ordinance (WDO) (Cap. 354) came into operation on September 1, 1996 (EPD, 1999). A ban on the importation of hazardous waste from developed (mainly OECD and European Union) countries was introduced on 28 December 1998. The controls are in line with the Basel

Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal.

4.7.3.3. DISCUSSION

The Basel Convention's main control mechanism requires notification and consent by authorities of the states of origin, destination, and transit before the shipment of hazardous or non-recyclable waste can begin. The import of hazardous or non-recyclable waste into or out of Hong Kong without a permit, regardless of the purpose of the import, is an offence under the WDO. Maximum penalties are a fine of $200,000 and six months' imprisonment for the first offence and $500,000 and two years for subsequent offences. In 1999, there were 24 convictions for illegal import or export of waste, with fines totaling $592,000. Also in 1999, a memorandum of understanding with the State Environmental Protection Agency of China provided an agreement on the control of hazardous waste shipments between the HKSAR and the Mainland.

4.8. Communication

4.8.1. Interview results

A successful demolition and construction waste management solution requires the input of all affected parties. These parties include all the groups of people that the team interviewed over the course of the project while in Hong Kong. The best way to display communication problems is the difference in opinions among the interviewed groups. Figures 4.6 through 4.9 show the results of questions on tipping fees and

sorting categorized by the different groups of people the team interviewed.

Figure 4.6 shows that the only group that currently has opposition to tipping fees is workers within the construction industry. Unfortunately, the team was unable to interview a waste hauler directly, but found that many people saw the waste haulers as the largest and only oppositions. However, this shows that people within the construction industry are also against such fees. Figure 4.7 displays how each group feels about the responsibility of who should pay these tipping fees. As can be seen in this figure, the majority of the groups interviewed believed that the construction companies should pay. The basic reason for this is that the persons doing the construction or demolition are the ones who

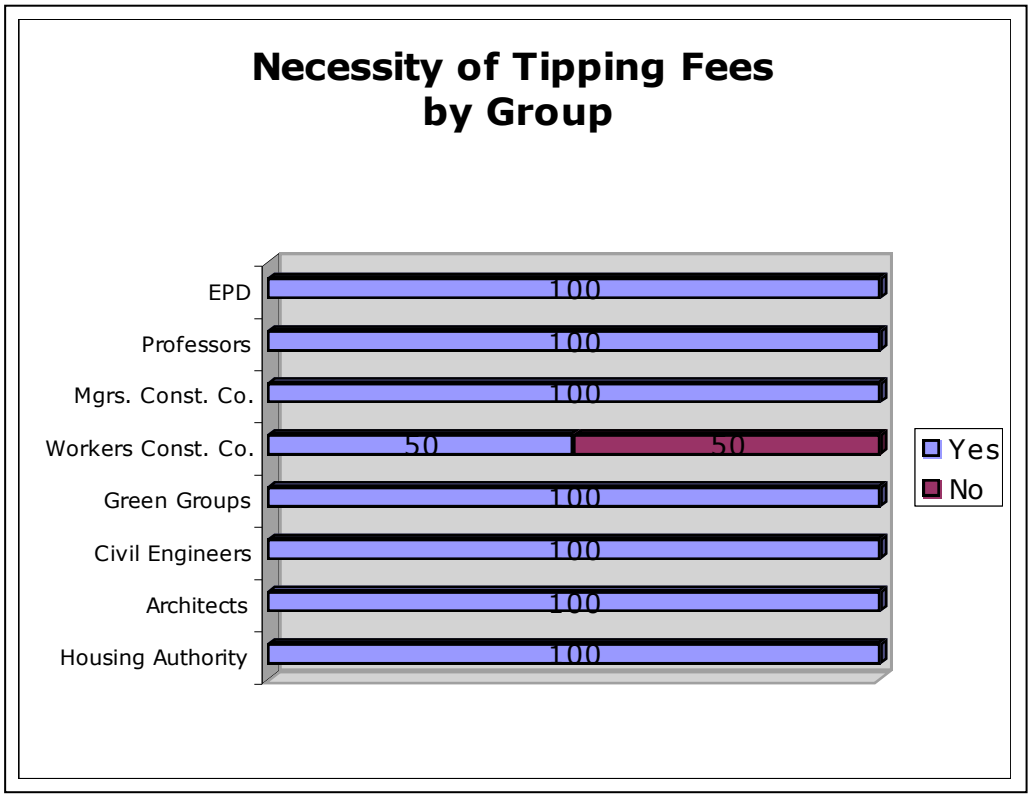


Figure 4.6. Necessity of tipping fees by group

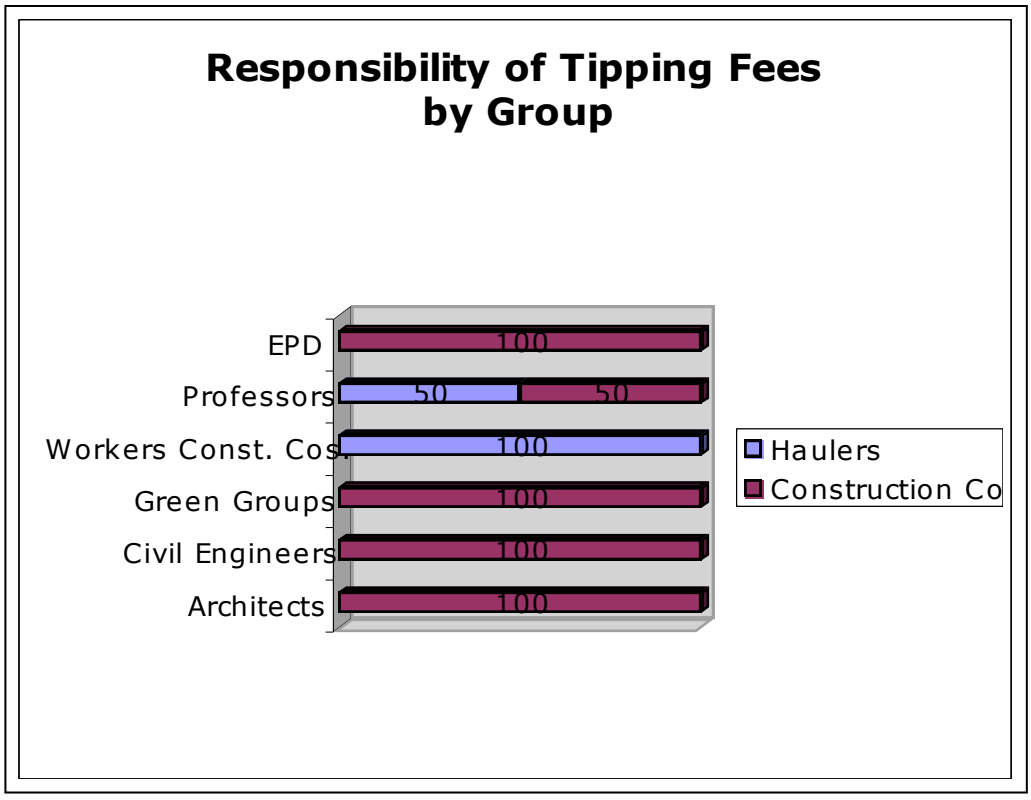


Figure 4.7. Responsibility of tipping fees by group

produce the waste in the first place. Therefore, they have the greatest opportunity to avoid and minimize it.

Figure 4.8 shows the breakdown by groups whether they felt sorting was necessary. From Figure 4.8 it can be seen that the majority of the groups interviewed found sorting to be a necessity. The general belief was that if C&D waste could be sorted efficiently, better quality public fill and recycled products could be produced, which would increase people's incentives to use them.

Figure 4.9 presents the differing opinions by group on where sorting should be done. Luckily, all of those that answered felt that off-site sorting was necessary. Also, some felt that on-site sorting would be beneficial.

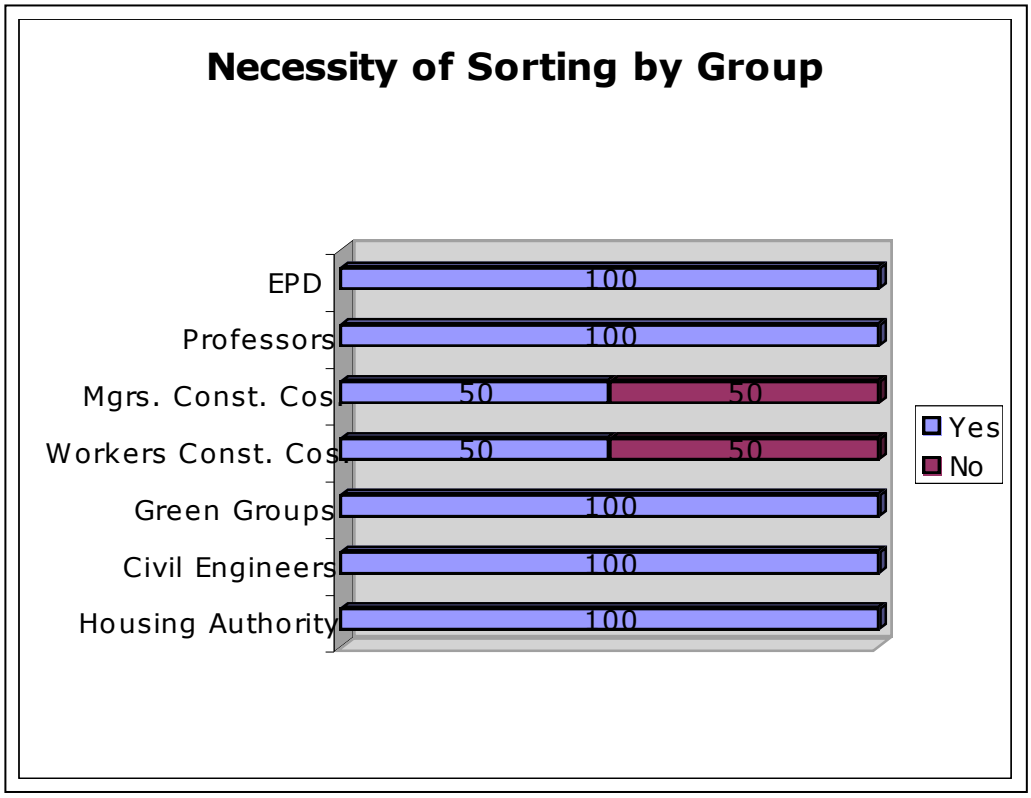


Figure 4.8. Necessity of sorting by group

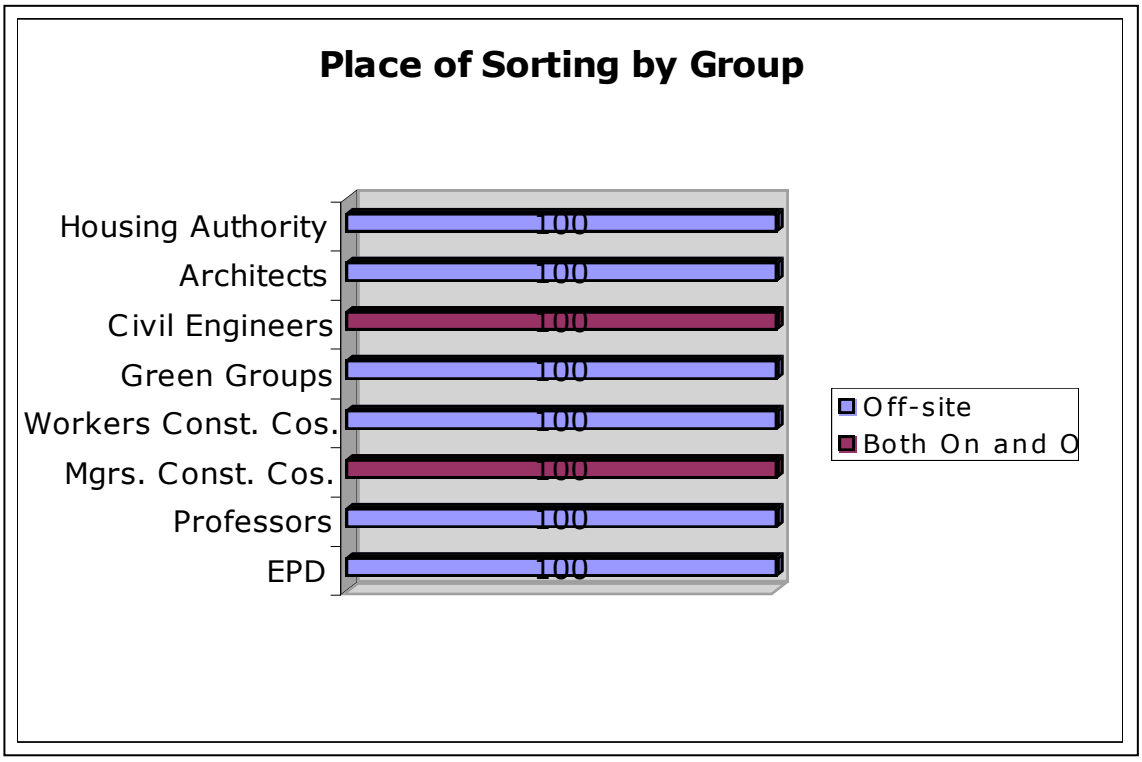


Figure 4.9. Place of sorting by group

4.8.2. Discussion

The absence of open communication between the many groups involved in construction and demolition waste management has caused many problems, such as tipping fee resistance and high amounts of mixed waste being brought to landfills. A much better system of communication must be found in order to achieve a situation where each person involved understands the goals of the community with respect to C&D waste management. This system would include information packets, open meetings, and increased awareness of problems through education.

Information packets on how C&D waste can be avoided, minimized, and recycled are currently in use by the EPD. These pamphlets dispatch information to different groups of people within the demolition and construction fields. The packets are very informative, but more such information should be made available to members of the industry. When information is made available on how C&D waste can be avoided, minimized, and recycled, however, there should be more details as to why such work should be completed. For instance, recycling packets currently available outline tips on what to recycle. Yet, these packets do not fully describe the reasons that such recycling is necessary. Also, other organizations, public and private, should become involved in the creation of these packets. In this way, adequate information will be available and it will be presented in a way that makes sense to the people that will read it.

In order to bring the different groups involved in the C&D industry together, public meetings should be held so that the government can get the input from different players within the group. These public meetings would foster the open communication necessary to aid the situation and would allow for different groups to get their questions answered and their concerns addressed. The meetings should take place at least once a month, and agendas made available online. Along with the agendas, there should be the minutes of the previous meetings, and a mailing list could be put together so that people can be informed when the information is available on the web site.

Finally, to encourage open communication with students who are about to enter the construction and demolition field, classes should be offered either at colleges or through the government on problems that must be addressed concerning the waste. In this way, the students will be more aware of what must be done at the work place to help the situation before they possibly get set in improper waste-handling methods. Such educational classes would also be able to provide the most recent information on the Hong Kong situation and describe any current technologies that are available for better recycling turnarounds.

These three resolutions will help to provide the C&D waste management situation with better communication. With an increase in communication comes a more realistic approach to solving the problems the industry is facing. The three ideas were presented in order of ease of establishment, and should be instituted in that order. With open communication, the industry can concentrate on the problems at hand.

The lack of public awareness of the situation is one of the main reasons that construction and demolition waste management issues are not considered a major problem in Hong Kong. Because of this, there is no push from the public to resolve these problems and it is therefore not a pressing issue for the government to resolve. Public awareness will allow the situation to be fully understood and will provide a path to finding a resolution to the issues in the current situation. Public awareness can be increased through an advertising campaign and through more projects like this one.

An advertising campaign would have to be instituted to get information out about the demolition and construction waste issues. Such a campaign would include information on what types of waste are generated during C&D processes, where this waste goes, and what problems currently exist in the industry. The hope would be that this information would get to many different groups within the industry, along with people within the general community. The main goal of this campaign would be to get information out to the general public about how each person can help with the situation, especially those that work in and around the construction industry.

Another way for public awareness to be increased is through other projects like this one. The aim of this project was to provide a critical review of the current situation. What this did was to show the issues, problems, and successes of the current construction and demolition waste management scheme. Other projects may concentrate on certain aspects of the industry, including those ideas revealed in this project. Through such research, information based on the projects' outcomes

would spread throughout the public. With advertising programs and an increase in waste management inspection projects, the public awareness of the situation will increase greatly.

Chapter 5. Conclusions and Recommendations

5.1. Conclusions

Based on the results obtained and the discussion provided, the following conclusions are made. These conclusions provide the foundation on which the recommendations are made.

5.1.1. Tipping fees

- Unlike most other countries, Hong Kong at present has no tipping fees for its landfills.

5.1.2. Waste minimization

- The guidelines, specifications, and policies for construction and demolition are only implemented by public projects
- There exist computer software packages that will help prevent problems such as over design in the market.
- Waste management plans are required for all public works projects. However, the waste management plans do not always make it clear as to exactly how the amount of C&D waste that is generated will be minimized and what will be done with any waste that is generated.
- Friends of the Earth's tile reuse program was the only program found that is geared to minimizing the amount of C&D waste entering landfills.

- Poor planning in the design stage of a construction project results in excessive waste being generated.
- Not enough construction companies make use of durable formwork, prefabricated parts, and metal scaffolding
- Excessive C&D waste is generated because contractors order more materials than they need.

5.1.3. Sorting

- C&D waste sorting is seen as a very important step in reducing the C&D waste stream.
- Due to the fact that space is very limited for construction projects, it is difficult to do onsite sorting.
- Selective demolition provides a very effective way to recover as much demolition waste as possible.
- Hong Kong's current sorting facilities sort C&D waste materials fairly effectively, but the general size of the facilities does not appear to be capable of handling Hong Kong's entire C&D waste stream.

5.1.4. Public fill

- Public fill is suitable for reclamation projects, but it is not always used due to the fact that the supply of public fill fluctuates, it does not settle as fast as ocean sand, and it is not as pure as it could be.
- In response to the fact that public fill capacity is running low, temporary fill banks are being established that will be used to store Hong Kong's excess public fill for the next three years.

5.1.5. Recycling

- Hong Kong currently has no recycling facilities for handling C&D waste but is planning to build some in the future.
- Hong Kong is currently researching various ways in which C&D materials can be recycled and is in the process of conducting pilot studies, but no active recycling programs for C&D waste exist.
- In order for recycling to be successful there needs to be a suitable market for recycled C&D waste products.
- The fact that Hong Kong's quarries are running out may result in more demand for recycled products.

5.1.6. Alternate waste handling methods

5.1.6.1. INCINERATORS

- Incinerators should not be the focus of waste reduction.
- Incinerators are a possible alternative to handling timber and packaging waste generated by C&D.

5.1.6.2. WASTE ISLAND

- As Hong Kong has very little remaining areas for public fill and waste, it may be necessary to reclaim land specifically for this purpose.
- This waste island should not be built unless there are no other alternatives.

5.1.6.3. EXPORTING WASTE

- Exporting waste is a good solution but costly.

- Many cities are having their own management problems of handling the waste.
- If possible, recycling the material could generate revenue rather than having to pay to remove the waste.

5.1.7. Communication

- There is a need for the improvement of communication between different players within the industry.
- Public awareness is an important part of the waste management program.
- Despite the various programs geared to increasing people's knowledge of Hong Kong's C&D waste problem, very few people are truly aware of how serious a problem it is for Hong Kong.

5.2. Recommendations

5.2.1. Waste Minimization and Avoidance

The government should consider providing more incentives and developing regulations on all construction projects to make use of high quality materials, durable formworks, prefabricated parts, and metal scaffolding in building construction. In addition, programs such as Friends of the Earth's tile collection program should be encouraged. Also, the use of computer programs that can help streamline the construction process and therefore minimize the amount of waste that is generated should be adopted by all construction projects. Furthermore, there need to be more efforts to educate the people of Hong Kong on how

important it is to reduce the amount of C&D waste that is generated each year. In general, construction companies should pay close attention to the exact amount of materials needed for the project and order only what they need. In addition, it should be clearly specified in a project's waste management program how waste will be minimized and what will be done with any waste that is generated.

5.2.2. Sorting

It is recommended that Hong Kong build bigger and more long-term sorting facilities for C&D waste. Since the majority of C&D waste comes from demolition projects, it is recommended that there be a greater emphasis on the practice of selective demolition.

5.2.3. Public Fill

Since virgin materials in reclamation projects come from ocean dredging and quarrying which can be detrimental to the surrounding ecosystems, it is recommended that public fill be used before virgin materials. The construction of temporary fill banks will help to hedge against fluctuations in the supply and the demand of public fill and thus will be very beneficial for Hong Kong.

5.2.4. Recycling

Hong Kong is planning to build recycling facilities, and it should make every effort to expedite the process. Recycling plants will provide alternative outlets for C&D waste and thus will reduce the amount of waste entering Hong Kong's three strategic landfills. In addition, the

government will need to make sure there are sufficient markets for the recycled products. The task of creating markets is quite difficult, and Hong Kong has a long road ahead.

5.2.5. Alternate waste handling methods

5.2.5.1. INCINERATORS

If Hong Kong decides to initialize use of incinerators, it should use small ones for easy maintenance and use the most modern incineration technologies.

5.2.5.2. WASTE ISLAND

The proposed waste island to be built off Lantau should only be considered if no other alternatives are available. If a project such as this is to be approved, then C&D public fill material should be used for reclamation, and careful measures should be taken to minimally disturb the ocean environment.

5.2.5.3. EXPORTING WASTE

Exporting waste to the mainland is recommended due to the fact that it is a more environmentally friendly alternative, rather than incineration or building a waste island.

5.2.6. Communication

Using the ideas discussed earlier, plans to put into place open forums, better informational pamphlets, and increased education on C&D waste in schools must be implemented. To complement these steps,

an advertising campaign and additional project like this one should be carried out.

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Appendix A. IQP Semantics

This project is for completion of Worcester Polytechnic Institute's Interactive Qualifying Project (IQP). An IQP challenges students to identify, investigate, and report on a self-selected topic examining how science or technology interacts with societal structures and values. The objective of an IQP is to enable WPI undergraduates to understand, as citizens and as professionals, how their careers will affect the larger society of which they are a part. This project is linked to technology and society by the fact that as society evolves on its current path, steps include the building of new structures to house technology-driven companies and people. With the building of these structures comes the waste of old buildings being demolished and leftover pieces from construction. Improper disposal of this waste pollutes the environment creating an unsustainable habitat for humans to live in. This degradation of living conditions counters the technological advances of civilization.

Appendix B. Background on Sponsoring Agency

Civic Exchange is an independent, non-profit, public policy think tank established with the mission to:

- Promote civic education, public awareness and participation in governance by strengthening civic participation in public life;
- Undertake research and development in economics, social and political policies and practices to help shape the breadth and depth of public policy debate and so to advance policies that are sustainable, resilient, non-violent, economically efficient, just, participatory, locally appropriate and spiritually rewarding; and
- Integrate skills and experiences across various disciplines including academia, business, politics, finance, technology and the non-profit sectors.

Christine Loh and Lisa Hopkinson founded civic Exchange in September 2000 (Civic Exchange, 2001). The organization is very open and their office is more like a clubhouse for people to meet to exchange ideas and share experiences. Workspaces are reserved for activities more than for specific individuals.

Appendix C. Work Plan

Week:	1	2	3	4	5	6	7	8
Conduct interviews with EPD and Waste reduction committee	X	X						
Interviews with Hong Kong Architects			X					
Interviews with construction companies			X	X				
Interviews with green groups				X	X			
Interviews with experts/professors				X	X			
Research Current Hong Kong Waste Management System	X	X	X	X				
Analyze data from interviews and Research				X	X	X	X	
Practice final Presentation						X	X	
Final Presentation								X
Report – Literature Review	X	X						
Report – Methodology		X	X	X	X			
Report – Results and Recommendations				X	X	X	X	
Report – Revisions						X	X	X

Appendix D. Sample Interview Questions (Pertinent to all groups)

1. What is your part in the recycling of construction and demolition waste? What technologies are you/your company utilizing?
2. Do you have a sufficient amount of money, manpower, land area, and technology?
3. Are C&D waste management policies in Hong Kong working? Do they have public backing? What incentives are used to get companies to recycle?
4. What do you believe are key elements for a good recycling program?
5. What would have to be implemented in order for Hong Kong to follow either a zero pollution policy or sustainable development?
6. Is the construction company, the customer, or the government responsible for the creation of and the costs related to C&D recycling?
7. Who is responsible for the transport of C&D waste to a recycling center? Who is in charge of recycling centers?
8. How would the creation of tipping fees affect C&D recycling? How would they affect the construction industry? Would the construction companies or their customers be responsible for this charge?
9. What references/experts do you recommend for further research?

Appendix E. Comparative Policy Analysis Table

	Hong Kong's Law	Taiwan's Law	New York City's Policies	Conclusion
Tipping Fee	No law as of yet.	Enforcing HK$45/tonne	Enforcing HK$60/tonne	Taiwan is able to enforce tipping fees to reduce waste
Reclamation	Size of 300,000 m^3+ should use public fill	No law as of yet.	Very strict policies, so few companies perform this work.	Hong Kong recommends use of public fill but not required
Waste Minimization	A waste minimization plan should be included with the planning	Plans enforced by the Taiwan EPA government called Industrial Waste Minimization	Recommends that all waste be minimized but no required	These cities are regulating laws regarding waste minimization
Incinerators	2 obsolete incinerators	21 modern incinerators	Not used within the city.	Taiwan reduces waste by cleanly burning waste generated
On site sorting	It is recommended that on-site sorting be done	It is recommended that on-site sorting be done	Sorting required.	In Hong Kong, C&D material sorting should be done

Appendix F. Environmental Protection Department Fact Sheets

(Please see the following pages.)

Appendix not included
in original submission

IQP/MQP SCANNING PROJECT