Evaluations of Existing Waste Recycling Methods: A Hong Kong Study

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Abstract

Environmental problems have been considered as a serious situation in Hong Kong construction. Waste management is pressing harder with the alarming signal warning the industry. Reuse, recycling and reduce the wastes consider as the only methods to recover those waste generated; however, the implementations still have much room for improvement. In order to ameliorate the existing situations, evaluations of the existing waste recycling methods are studied in this research. A telephone interviewing to the recyclers, site visits to the construction and demolition sites (including the Lower Ngau Tau Kok Estate Phase 1) and the centralized recycling plant in Tuen Mun Area 38 are under investigation. Difficulties encountered for various recycling parties are investigated. Rather than the poor quality found from the recyclable materials, they found the high investment cost, lengthy demolition period and limited space caused the major barriers for them. Therefore, some recommendations are suggested: i) proposing a higher landfill charging scheme; ii) setting up a centralized centre for recycling the materials; iii) examining the Hong Kong government should be supported in the provision of land for recycling plants; iv) implementing innovative demolition methods; v) allowing some locations in town for residents' easy access to drop-off recyclable materials; vi) allowing flexible demolition periods; vii) setting up recycling plant in town or in the form of mobile installations; viii) reusing the reusable components as donations to the charity organization; ix) providing higher flexibility in receiving concrete waste in Tuen Mun Area

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38 recycling plant; and x) balancing the supply and demand of recycled materials through legislations or incentive schemes.

Keywords: Recycling, waste management, environment, construction, Hong Kong

1. Introduction

The promotion of environmental management and the mission of sustainable development have exerted the pressure demanding for the adoption of proper methods to protect the environment across all industries including construction. Construction by nature is not an environmental-friendly activity. The hierarchy of disposal options, which categorizes environmental impacts into six levels, from low to high; namely, reduce, reuse, recycle, compost, incinerate and landfill [1] (see Figure 1). Three main waste minimization strategies of reuse, recycle and reduction, are collectively called the “3Rs”. To reduce construction waste generated on site, coordination among all those involved in the design and construction process is essential.

<Figure 1>

Recycling, being one of the strategies in minimization of waste, offers three benefits [2]: i) reduce the demand upon new resources; ii) cut down on transport and production energy costs; and iii) use waste which would otherwise be lost to landfill sites. Construction and demolition (C&D) wastes including demolished concrete (foundations, slabs, columns, floors, etc), bricks and masonry, wood and other materials such as dry wall, glass, insulation, roofing, wire, pipe, rock and soil [3] constitute a significant component of the total waste.

In order to improve the existing practices of waste recycling, this paper focuses on the following objectives:

i) Investigating the waste problems in construction;

ii) Examining the importance on waste recycling;

iii) Exploring the existing waste recycling methods by telephone-interviewing recyclers and visit to C&D sites and centralized recycling plant; and

iv) Pinpointing the difficulties encountered from the existing waste recycling methods, the recovery methods for the current waste recycling market are suggested.

2. Construction Wastes Problem

Waste is defined as any material by-product of human and industrial activity that has no residual value [4]. From the statistic of EPD [5] (Table 1), 38% of the wastes are generated from C&D activities, which is around 6,408 tons of wastes per annum are produced from construction activities. In 2001, the quantities of the ferrous metals represented at 45.5% with 803,190 tons of the total recyclable materials and 37.7% with 665,539 tons from wood and paper. Non-ferrous metals have the higher values of recyclable volume, in which it valued as one thousand million (Table 2). For the total recyclable materials, ferrous metals, non-ferrous metals, wood and paper are incorporated to 87.1% of the total quantity of exported recyclable materials and 87.2% of the total values of the materials. Therefore, it is necessary to reduce the waste generated of those three categories of materials for effectively and efficiently reduce the problem in wastage.

<Table 1>

<Table 2>

A comprehensive construction waste management is urgently needed on every construction site. After identifying the causes of construction waste, it is of great importance to structure

ways to minimize it as the most favorable solution to waste problem of any kind. Indeed, it should be made compulsory that every construction company should enact construction waste management plan tailored to its particular mode of business so that every personnel from the management to the operational level can head for the same goal of construction waste management. Besides reduction strategies, economic issues in construction waste management in terms of recycling and contractual implications also play a significant role.

3. Construction Waste Recycling

Table 3 shows the recovery rates of several types of materials, such as paper, plastic, metals and glass, in Hong Kong, Australia, Japan, USA, Germany and United Kingdom. Germany clearly has the highest recovery rates when compared with other countries; 169%[1], 108%, 105% and 88% of recovery rates for paper, plastic, metals and glass respectively.

<Table 3>

Hong Kong recycling practices is lagging behind in comparison with other countries. Much of the construction wastes go to landfill. There are many opportunities for the industry to act to minimize this [6] in order to prolong the life of landfill sites, minimize transport needs and reduce the primary resource requirements (mineral and energy).

Although there are many material recycling schemes recommended by the Hong Kong government with some practices examples listed in Table 4, actual administering of C&D waste recycling is limited to a few types of solid wastes. When considering a recyclable material, three major areas need to be taken into account [7]: i) economy; ii) compatibility with other materials; and iii) material properties. From a purely economic point of view, recycling of C&D waste is only attractive when the recycled product is competitive with

natural resources in relation to cost and quantity. Recycled materials will be more competitive in regions where a shortage of both raw materials and landfilling sites exists.

<Table 4>

4. Existing Waste Recycling Methods

The economic and environmental benefits to be gained from waste minimization and recycling are enormous [8], since it will benefit both the environment and the construction firms in terms of cost reduction. The economic benefits of waste minimization and recycling include the possibilities of selling specific waste materials and the removal from site of other wastes at no charge or reduced cost, with a subsequent reduction in materials going to landfill at a higher cost [9]. Therefore, it can increase contractors' competitiveness through lower production costs and a better public image. However, very few contractors have spent efforts in considering the environment and developing the concept of recycling building materials [10]. Because contractors rank timing as their top priority, their effort is always focused on completing the project in the shortest time, rather than the environment [11-12]. Their account books cannot reveal the potential savings resulted from reduction in construction wastes. Managing building material waste can in fact achieve higher construction productivity, save in time and improvement in safety [13-15] while extra wastes take extra time and resources for disposal that may slow down the construction progress.

In the examination on the current situation on waste management and recycling in the construction industry, telephone-interviewing with recycling firms, interviewing with the representatives and site visits to six local C&D sites (including the selective demolition site at Lower Ngau Tau Kok Estate Phase 1), one overseas construction site and Tuen Mun Area 38

centralized recycling plant, are conducted. Their difficulties encountered in the practices of waste management and recycling are highlighted.

4.1 Data Collected from Survey with Recycling Firms

In order to investigate the current status of recycling construction wastes in Hong Kong, a survey from telephone conversation had been conducted. The main objective is to examine the acceptable recyclable construction materials, the collection location and the price for these recycling materials. The survey was undertaken by telephone-interviewing two hundred and sixty-five recycling organizations. Ninety-four recycling firms completed this survey and used for analysis, one hundred and fifteen recycling firms were not completed, and the remaining fifty-six recycling organizations were not in business. The recycling organizations were chosen from the Lists of Recycling Company approved by the Environmental Protection Department of the Hong Kong Special Administrative Region (SAR) [5]. Furthermore, seven recycling companies were interviewed for clarifying and discussing the current status, difficulties and possibility for further improvement in the recycling culture in Hong Kong.

From the survey, most of the recycling materials are ferrous and non-ferrous metals, which included 19.92% and 22.31% respectively (see Table 5). Paper, plastic and computer product are also considered for recycling with 17.93%, 15.14% and 11.16% respectively. In the discussions with the interviewees, the recycling materials will normally be transported to Guang Dong, Mainland China, where labour cost is low. Although Mainland China is likely to receive recycling materials, she is not a free export and import country. Extensive procedures, including tax and permits in transporting these materials, are needed. Furthermore, difficulties may arise sometimes, if Mainland China has not heard of new recycling technology. For example, a new method that recycles plastic bottles by cutting

them into pieces, may encounter problems when transporting these recycling materials into China as she is afraid of dumping these “recycling materials” into their landfill areas and affecting their environment. Furthermore, the recyclers argued that set up recycling plant is difficult in Hong Kong, as the land cost is unaffordable for developing such a non-profitable industry.

<Table 5>

Although various types of materials are recycled, C&D wastes will not be considered by around half of the recycling companies with 45.74% (see Table 6). The recyclers explained that the control of impurities and thus the need for sorting are the major reasons. As discussed with the construction organizations, they will initially recycle the profitable materials, including metal and electric cable. Other recyclable materials, such as bamboo scaffolding, coverage material, hoarding and cover-walkway will normally be reused for other similar projects. Other materials, including tile, finishes, brick and block, may usually end up in landfill areas.

<Table 6>

Many of the recycling companies (34.04%) will require construction organizations to sort out the wastes before collection (see Table 7). In the discussions with recyclers, the profit made from recycling market is not high; the recycling companies cannot provide resources in sorting various types of materials. Thus this responsibility is shifted to the construction organizations. The construction organizations are encouraging to sort various types of C&D materials during demolishing, in which the newly adopted “selective demolition method” can facilitate the sorting procedures and improve the recycling rate.

<Table 7>

Furthermore, most of the recycling companies will not restrict the minimum quantity for the recycling materials (see Table 8). While some of the recycling companies will depend on distance and situation. In interviewing one of the recycling firms, he explained that the limit on receiving recycling materials, particularly on the low-value materials, should be predetermined. Otherwise, the costs for transportation and labour may exceed the cost of reclaimed wastes. For the valuable and profit-making recycling materials, such as ferrous and non-ferrous metals, and electricity cable, both the construction organizations and recyclers will actively receive it even the quantity is very low. Furthermore, wide price ranges are found in this survey, which can vary up to ten times. The recyclers explained it may be due to the seasonal variations.

<Table 8>

Most of the recycling companies (84.69%) will allow receiving the materials from everywhere in Hong Kong (see Table 9). Although the recycling companies will receive materials everywhere in Hong Kong, the waiting time for receiving these materials still need to be concerned. As explained by one of the recyclers, the recycling companies will normally wait for receiving materials from various construction sites if the quantity cannot fully full-up the truck. However, poor construction site conditions may impose difficulty of prolonging the waiting time for waste collection.

<Table 9>

In order to send these recycling materials to the recyclers, nearly half of the recycling companies (57.45%) will freely provide transportation and labour (see Table 10). However, 22.34% of the recycling companies will require charge for receiving these materials; the price range is from HK$50 to HK$400 per ton, which depends on the distance and types of

materials. For examples: collection of plastic bottle needs a higher transportation and labour fee as these consumes lot of spaces with only a light weight; the ferrous and non-ferrous metals are received at a lower unit charge.

<Table 10>

In the discussions with recycling companies, several difficulties in the current recycling market have been identified:

(a) The construction organization considers environmental management as a non-profitable activity. The construction industry lacks environmental awareness, including separation and sorting various types of C&D materials.

(b) The regulations and legislations related to environmental matters implemented by the Hong Kong government are too liberal. If regulated by non-mandatory schemes, construction organization is reluctant to implement the high-investment environmental management measures.

(c) The recycling market lacks a centrally coordinating party. Some of the construction organizations found difficulty to find suitable recyclers and receive various types of construction materials.

(d) In an immature recycling environment and market, it is difficult to afford the high investment costs on facilities, equipments, land and labour.

(e) Hong Kong's recycling market is restricted to those recycling materials which have a high scrap value; other non-profitable but recyclable materials are not being considered. Some of the sorted but non-profitable materials will still be sent to dumping areas.

(f) In recycling concrete wastes, Tuen Mun Area 38 recycling plant is restricting the minimum size of the demolished concrete to 250mm. The construction organization

explained that the stringent requirement on the acceptable minimum size of concrete wastes.

(g) The fundamental encouragement in proposing landfill charging scheme is improving the sorting situation and the recycling rate in Hong Kong. However, the construction organizations argued that it may only increase the processing cost, which however may simply be transferred to the clients and reflected in the tender price.

4.2 Data Collected from Visits to the C&D Sites

Five site visits are conducted with the aid of the Housing Authority (HA) of the Hong Kong SAR; details of which are summarized in Table 11. From the discussions with the representatives of five HA C&D sites and the investigators' observations, the recycling materials of the five sites are limited to concrete and reinforcement bars with the former being a request from HA or forming one of the contract conditions and the latter for the economic value. However, with a lack of financial incentive, the recycling rates of the other low-valued construction debris were low. For Construction Site 5, an efficient environmental plan was established, in which all types of construction wastes were separated and packed with bags that were dumped through the refuse chute at different time slots as defined in the plan leading to efficient collection of completely separated wastes. However, these wastes could not all end up being recycled due to the lack of interests from recycling companies or the lack of relevant recycling plants.

<Table 11>

The main problems hindering waste recycling identified from the site visits which were also confirmed by Kasai [16] are:

(a) Limited space on site makes sorting and separation of C&D wastes difficult.

(b) Demolition activities in urban areas normally restricted in time because the clients usually want to clear the site out in a tight demolition duration in order to minimize nuisance to the public, opportunities for vandalism, and traffic congestion created around the site.

(c) Cost is one of the important factors. Knocking down the structure as quickly as possible is the most efficient and cheapest method of demolition. The demolition wastes are then removed in the state (fully mixed) that they arose. Only materials with market values are removed from the building first.

(d) Lack of recycling plants and facilities is encountered in Hong Kong, especially for those which may generate hazardous substances.

(e) Imbalanced supply and demand of recycled products is investigated. It may be difficult to find outlets for the recycled materials. Construction organization also finds difficulty in locating salvage collectors or recyclers, which may be due to the lack of coordination in the recycling industry.

(f) Quality requirements of the recycled materials may also form a hurdle of in marketing recycled products.

(g) Lack of standards for the recycled products hinders their adoption.

(h) Reuse and recycling technologies are not well-established.

(i) Harmful materials may be released from the recycling processes.

4.3 Data Collected from Visit to the Selective Demolition Site at Lower Ngau Tau Kok Estate Phase 1

The HA of the Hong Kong SAR has a trial implementation of selective demolition method in demolishing a school project at Lower Ngau Tau Kok Estate Phase 1. Different types of

materials are sorted, including timber, steel, florescent tube, electricity fitting, toilet set, red brick, tile, finishes, drainage pipe, cable, etc. However, the sorted materials finally dumping as waste rather than reused by recycling companies. The cost and time utilized in this process were found to have increased by more than one hundred percent. Therefore, the implementation of the selective method by legislative tools is encouraged; otherwise the construction industry is reluctant to adopt this demolition method.

4.4 Data Collected from the Visit to Recycling Plant at Tuen Mun Area 38

A visit to the centralized recycling plant at Tuen Mun Area 38 was conducted on 19 June 2003. The plant started operating in July 2002 and planned to close in October 2004 originally and now extended to June 2005, which is the first trial recycling plant for demolished concrete (details are summarized in Table 12). Since it is a trial recycling plant organized by the Hong Kong government, all the recycled aggregate produced will freely provide to other government departments, for examples, Architectural Services Department and Buildings Department of the Hong Kong Special Administrative Region. This recycling process goes through two types of crushers: jaw crusher and cone crusher, in which the jaw crusher is used to reduce the sizes of the wastes and the cone crusher is used to ensure all wastes being crushed into the required sizes. Some of the demolition projects from the HA of the Hong Kong SAR delivered concrete waste with a minimum size of 250mm to the plant. Forty percent of the concrete wastes supply came from public works while the other sixty percent was from private organizations. However, those coming from private organizations need some sorting before feeding into the plant. Six hundred to twelve hundred tons of recycled aggregate can be produced daily provided that the supply can provide enough quantities. The recycled aggregate is mainly used as new concrete; 1% for foundation, retaining wall, ground beam, and pile cap, 15% for drainage surround and haunching, 50%

for rockfill and filter layers, 15% for sub-base and 20% for paving block. As discussed with the representatives of the recycling plant and our observations, the following difficulties were encountered in recycling concrete wastes:

(a) Recycled aggregate has higher water absorption values, as a result, higher demand for water, and longer mixing time required. Construction practitioners lack experience in managing and using the recycled aggregate.

(b) The concrete wastes collected is composed of more than fifty percent of rock, with only a small amount coming from demolished sites, which may distort the interpretation of the results.

(c) It takes a long time to travel from demolition sites in town to the recycling plant. As a result, higher transportation costs (truck drivers complained about a maximum of two round trips a day) and heavier loading on the public transport system (traffic congestion to the Tuen Mun Highway) increase the cost of production, both economic and social, of recycled aggregate.

(d) The stringent requirements on the sizes of concrete wastes (250mm or above) form another hurdle because: a) dropping of concrete wastes from height during demolition will reduce their sizes; and b) the demolition contractors in the process of salvaging reinforcing bars need to reduce the sizes of concrete wastes.

<Table 12>

5. Improving the Current Status in Recycling Markets

After the brief discussions with the recyclers, the representatives from C&D sites and Tuen Mun Area 38 centralized recycling plant, it was determined that there are several ways in improving the current status of recycling market:

(a) Although the proposed landfill charging scheme provides a positive initiative to recycle C&D wastes for the construction organizations, the cost should be balanced between the transportation cost with the charging amount and the labour cost for sorting and separating C&D materials. Therefore, a higher landfill charging scheme is proposed.

(b) Since the construction organizations found difficulties in searching suitable recyclers in receiving various types of recyclable C&D materials, a centralized center should be set up for recycling various types of materials.

(c) With the high land cost in Hong Kong, recyclers got financial problems in implementing the recycling industry, which has a very thin profit margin. Support from the Hong Kong government in the provision of land for recycling plants should be established.

(d) For improving the recycling rate of the demolition activities, innovative demolition methods should be implemented: i) selective demolition method or other suitable demolition methods are encouraged for sorting and separating construction materials during demolition; and ii) a newly adopted demolition method in Japan called “Move Hat” uses a “Hat” to cover the part of the demolishing building and cutting the building by layer. This is good at reducing noise and dust emissions and facilitating sorting in construction sites.

(e) In order to gain the benefits of selective demolition, there should be some locations in town allowing residents’ easy access to drop-off recyclable materials. By the ways, it may be necessary to work with some incentive programmes.

(f) From the discussions with the construction organizations, they stated that tight demolition period was impossible to sort various types of reusable and recyclable

materials in the construction sites. The clients should allow flexible demolition periods for contractors having sufficient time in separating all recyclable materials.

(g) Although there is a recycling plant in Tuen Mun Area 38 in recycling demolished concrete in Hong Kong, long transportation time creates difficulties. The recycling plant should be set up in town or in the form of mobile installations.

(h) Some of the C&D materials may not have recycling market in Hong Kong. Some reusable components can be reused as donations to the charity organizations. For examples: selective demolition can provide opportunities to reuse the old air-conditioners.

(i) Since the size restriction (at least 250mm) for the demolition concrete is imposed in Tuen Mun Area 38 centralized recycling plant, construction organizations found difficulties in achieving the controlled size. Higher flexibility should be applied in receiving concrete waste in Tuen Mun Area 38 recycling plant.

(j) It is necessary to balance the supply and demand of recycled materials through legislations or incentive schemes.

6. Conclusion

As environmental protection had been pressing hardly in all over the world, the pollution generation from construction activities seems difficult to control; while waste problem is the major element in the pollution generation. For controlling the waste generation in Hong Kong construction, reuse, recycling and reduce the construction materials had been encouraged. However, the existing waste recycling methods did not encourage the various recycling parties and encountered difficulties from various directions. Therefore, some recommendations are suggested: i) proposing a higher landfill charging scheme; ii) setting up a centralized centre for recycling the materials; iii) examining the Hong Kong government

should be supported in the provision of land for recycling plants; iv) implementing innovative demolition methods; v) allowing some locations in town for residents' easy access to drop-off recyclable materials; vi) allowing flexible demolition periods; vii) setting up recycling plant in town or in the form of mobile installations; viii) reusing the reusable components as donations to the charity organization; ix) providing higher flexibility in receiving concrete waste in Tuen Mun Area 38 recycling plant; and x) balancing the supply and demand of recycled materials through legislations or incentive schemes.

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Table 1: Quantities of Solid Waste Disposed of at Landfills in 2001 [17]

Waste type	Quantity (tpd)		
	Public	Private	Total
(a) Domestic waste			
- waste from household, public cleansing	5,822	1,644	7,466
- bulky waste	28	57	85
Sub-total	5,850	1,701	7,551
(b) Commercial waste			
- mixed waste from commercial activities	-	1,120	1,120
- bulky waste	-	68	68
Sub-total		1,187	1,187
(c) Industrial waste			
- mixed waste from industrial activities	-	534	534
- bulky waste	-	28	28
Sub-total		562	562
(d) Municipal solid waste received at disposal facilities (a+b+c)	**5,850**	**3,450**	**9,300 (55%)**
(e) Construction and demolition waste (landfilled)	**-**	**6,408**	**6,408 (38%)**
(f) Special waste (landfilled)	**502**	**607**	**1,109 (7%)**
(g) All waste received at landfills (d+e+f)	**6,352**	**10,465**	**16,817**

Notes:

- Public waste collectors are waste collected by Food and Environmental Hygiene Department contractors and other government vehicles
- Publicly collected domestic waste included some commercial and industrial waste
- Special waste included abattoir waste, animal carcasses, asbestos, clinical waste, condemned goods, livestock waste, sewage treatment and waterworks treatment sludge, sewage works screenings and stabilized residues from Chemical Waste Treatment Centre

Table 2: Quantities and Values of Exported Recyclable Materials by Type [17]

Category of recyclable materials	Quantity (tons)	Value ($ thousand)	Value per unit weight ($ / ton)
Ferrous metals			
- alloy steel scrap	16,471	72,171	4,382
- pig or cast iron	42,970	46,667	1,086
- tinplate	572	1,134	1,983
- other scraps	743,177	606,669	816
Sub-total	803,190 (45.5%)	726,641 (27.9%)	905
Non-ferrous metals			
- aluminum	17,044	69,285	4,065
- copper and alloys	47,580	296,645	6,235
- lead	2,785	4,424	1,589
-metal ash and residues	226	13,144	58,159
- nickel	63	1,273	20,206
- precious metal	117	656,386	5,610,137
- tin	2	39	19,500
- zinc	1,270	11,251	8,859
Sub-total	69,087 (3.9%)	1,052,447 (40.4%)	15,234
Plastics			
- polyethylene	115,653	124,594	1,077
- polystyrene and copolymers	18,445	48,076	2,606
- polyvinyl chloride	2,234	5,065	2,267
- others	71,401	120,381	1,686
Sub-total	207,733 (11.8%)	298,116 (11.4%)	1,435
Textiles			
- cotton	16,539	25,746	1,557
- man-made fibres	57	295	5,175
- old clothing and other textile articles, rags, etc	3,434	11,700	3,407
Sub-total	20,030 (1.1%)	37,741 (1.4%)	1,884
Wood and paper			
- paper	657,336	487,785	742
- wood (include sawdust)	8,203	4,274	521
Sub-total	665,539 (37.7%)	492,059 (18.9%)	739

Table 3: Recovery Rates of Common Recyclable Materials [5]

Place	Year	Paper	Plastic	Metals	Glass
Hong Kong	2001	58%	38%	89%	3%
Australia	1995	51%	30% (Polyethylene Terephthalate (PET) bottles) 42% (High-density polyethylene (HDPE) bottles)	65% (Aluminium (Al) can) 23% (others)	42%
Japan	2000	58%	14%	75%	78% (glass bottles)
USA	1999	42%	6%	35%	23%
Germany	1999	169%[1]	108%	105% (finplate) 87% (Al can)	88%
United Kingdom	1998	38%	3%	43% (Al can) 35% (ferrous scrap)	22%

[1] Percentages greater than 100% mean materials being recycled for more than one time.

Table 4: Recycled Materials for Construction Industry [5]

Recycled Materials	Uses	Local Examples
Aggregates	Sub-base material for road construction, hardcore for foundation works, base / fill for drainage, aggregate for concrete manufacture and general bulk fill	Pilot studies carried out by works department
Asphalt	Aggregate fill and sub-base fill	Under investigation by Highways Department
Excavated Materials	Filling materials	Housing Department's building projects
Public Fill	Land reclamation	Land formation of public filling areas
Pulverized Fuel Ash	Manufacture of concrete products, uses in fill and reclamation, highway construction and reinforced soil structures	Construction of Chek Lap Kok Airport, use in structural concrete for foundation works in the Housing Department's building projects
Metals	Manufacture of new metals	Widely practiced in the local construction industry
Glass	Substitute for sand and aggregates as pipe-bedding material, gravel backfill for walls, crushed stone surfacing, backfill and bedding	Nil
Plastic	Synthetic materials in form of plastic lumber for landscaping, horticulture and hydraulic engineering	Use at some public recreational facilities as garden furniture
Rubber	Manufacture of rubber slate tile use in roofing and sport / playground surface mat	Use at some public recreational facilities as playground surface mat
Expanded Polystyrene	Manufacture of lightweight concrete for non-structural works	Use in manufacturing lightweight concrete in Housing Department's building projects

Table 5: Survey Results on Recycling Materials

Recycling Materials	Numbers of Responses	Percentages
Ferrous Metals	50	20.75%
Non Ferrous Metals	56	23.24%
Textile	10	4.15%
Plastic	36	14.94%
Paper	43	17.84%
Electrical Appliances	13	5.39%
Computer Products	26	10.79%
Timber	1	0.41%
Rubber / Tyre	4	1.66%
Glass	2	0.83%
Total	241	100.00%

Table 6: Survey Results on Receiving C&D Materials

	Numbers of Responses	Percentages
Yes	51	54.26%
No	43	45.74%
Total	94	100.00%

Table 7: Survey Results on the Requirement of Sorting

Requirement	Numbers of Responses	Percentages
Sorted Before Delivering	32	34.04%
Not Required to Sorted	28	29.79%
Only Receive One Type of Recycling Material	28	29.79%
No Information	6	6.38%
Total	94	100.00%

Table 8a: Survey Results on the Minimum Quantity Required on Recycling Materials

Material Types	Ferrous Metals	Non ferrous Metals	Textile	Plastic	Paper
	Numbers of Responses				
No Minimum Quantity Required	28	32	1	15	24
Less Than 1 Ton	7	8	2	5	6
1 Ton to 50 Tons	13	15	2	11	10
No Information	0	0	0	1	0
Depended on the Distances and Situations	2	1	5	4	3

Table 8b: Survey Results on the Minimum Quantity Required on Recycling Materials

Material Types	Electrical Appliances	Computer Products	Timber	Rubber / Tyre	Glass
	Numbers of Responses				
No Minimum Quantity Required	8	17	1	4	1
Less Than 1 Ton	0	0	0	0	0
1 Ton to 50 Tons	4	6	0	0	0
No Information	0	1	0	0	0
Depended on the Distances and Situations	1	2	0	0	1

Table 9: Survey Results on the Location Receiving Recycling Materials

Locations	Numbers of Responses	Percentages
All Hong Kong Island, Kowloon and New Territories	83	88.30%
Hong Kong Island and Kowloon	2	2.13%
New Territories and Kowloon	2	2.13%
Hong Kong Island Only	1	1.06%
Kowloon Only	3	3.19%
New Territories Only	1	1.06%
Take to the Recycling Company	1	1.06%
Only Receives Overseas Materials	1	1.06%
Total	94	100.00%

Table 10: Survey Results on the Requirements for Transportation and Labour

Requirements	Numbers of Responses	Percentages
Charge for Transportation and Labour	21	22.34%
Free Transportation and Labour	54	57.45%
Depended on Distance	7	7.45%
No Information	3	3.19%
To be Delivered by Contractor	7	7.45%
Commercial Secret	2	2.13%
Total	94	100.00%

Table 11a: Summary on Information Collected from the Visited Construction and Demolition Sites

	Demolition Site 1	Demolition Site 2	Demolition Site 3	Demolition Site 4	Construction Site 5
Site Details	Six residential blocks of eleven-storey high	Five residential blocks of twelve-storey high and one block of school	Two residential blocks, one school and two playgrounds	Five residential blocks, three schools, one public facility and four markets.	Two residential blocks and one intersection block of 41-storey
Years of Service	45 years	35 years	36 years	36 years	Not applicable
Waste Separation	(i) Inert waste (concrete, blocks) (10,210m^3) (ii) Non-inert waste (timber, furniture) (735m^3) (iii) Heavy metals (reinforcement)	(i) Inert waste (ii) Non-inert waste	(i) Inert waste (9,600m^3) (ii) Non-inert waste (38,400m^3) Before demolition, contractor invited recycling companies to collect furniture, electricity cable, window, door sets, steel, copper, aluminium, steel, zinc, etc. Fluorescent tubes were sent to Tsing Yi for treatment before dumping.	(i) Inert waste (14,000m^3) (ii) Non-inert waste (56,000m^3)	Nearly all types of wastes are separated, such as concrete, tile, plastering, paper-board, and cement packaging bags. But most would be dumped into landfill and public filling areas, of around 250m^3 of inert and non-inert waste sent to landfill per month.
Recycling Rate	• 6% on concrete (around 105m^3 of recycled concrete collected per blocks with a total of 630m^3) • Nearly 100% on reinforcement	• 50% on concrete (around 4,900 m^3 of recycled concrete collected per blocks with a total of 24,500 m^3) • Nearly 100% on reinforcement (around 300 tons of reinforcement collected per block and a total of 1,500 tons)	Only recycle concrete (about 10% for high-levels and 40% for low-levels) and reinforcement	Only recycle reinforcement	• About 85% waste generation comes from concrete and cement

Table 11b: Summary on Information Collected from the Visited Construction and Demolition Sites

	Demolition Site 1	Demolition Site 2	Demolition Site 3	Demolition Site 4	Construction Site 5
Salvage Cost of Reinforcing Bars	Steel reinforcing bars @ $0.4/kg Mixed steel @ $0.2/kg	Steel reinforcing bars @ $0.4/kg Mixed steel @ $0.2/kg	No information	No information	Not applicable
Difficulties Encountered	The demolished debris was composed largely of broken bricks (commonly used in the late 50s and the 60s as infill panels). The mixing of concrete with broken bricks created difficulties in sorting and, therefore, a relatively low recycling rate was recorded.	As the recycling plant at Tuen Mun Area 38 only accepts concrete with a size of 200mm or bigger, the concrete debris (low strength concrete) dropped from a height has broken into small pieces, making it difficult to maintain a size of 200mm.	Same as Site 2. Further, the salvage of reinforcing bars from concrete needs to reduce the size of concrete waste. As a result, debris needs to be broken down to a size smaller than 200mm.	The project did not have any recycling requirements.	No recycling outlets for low-valued salvage.
Project Staff's Opinion on Recycling	• Uneconomic due to high labour cost in sorting • Site space constraints • Long traveling time to Tuen Mun Area 38 causing traffic congestion to the road system	• Uneconomic due to high labour cost in sorting	• Uneconomic due to high labour cost in sorting • Site space constraints • High transportation cost to Tuen Mun Area 38	• Site space constraints • Time and cost will be increased if site sorting is carried out	• Adopting prefabrication and steel formwork can reduce site wastage • Timber is the most un-environmentally friendly material and other substitutes such as steel and aluminium should be proposed • Direct employed labour are easier to control and with lower material wastage • Packing debris into bags and delivering them using material hoist, rather than refuse chute, can provide effective sorting
Contract Requirements	Concrete waste to be sent to Tuen Mun Area 38 for recycling	Concrete waste to be sent to Tuen Mun Area 38 for recycling	No contract requirements but the contractor sent concrete waste to Tuen Mun Area 38 for recycling voluntarily	No contract requirements on recycling	No contract requirements on recycling

Table 12: Summary on Site Visit to Recycling Plant at Tuen Mun Area 38

Site details	The Plant started operating in July 2002 and targeted to close in October 2004.
Received wastes	20% hard inert C&D waste for making recycled aggregate; other 80% are too fine or made up of mud and can only be used for landfill
Supply of wastes	- Private (60%) and public (40%). - Intake from private normally needs further sorting (uneconomic). - No seasonal change in supply, which is mainly affected by the number of demolition sites. - C&D waste is composed of 50% concrete waste and 50% stone or boulders.
Production rate	- 600 tons daily (max. 1200 tons), due to inadequate supply of waste. - No charge for supplying to government projects (including KCRC and MTRC) and private projects (backfill and hardcore).
Applications	- New concrete (1%) as foundation, retaining wall, ground beam, pile cap. - Drainage surround and haunching (15%) - Rockfill / filter layer (over 50%) - Subbase (15%) - Paving blocks (20%) (under research) (<=5mm aggregate for replacing sand) (CSD and KCRC are conducting the trial)
Difference between natural aggregate and recycled aggregate	- Higher water absorption rate - Higher demand for water - Longer mixing time - Operational cost increased
Crushers	Jaw crushers (first pass) to make G200 boulders and cone crushers (second pass) for crushing to the required sizes; i.e., 40, 20, 10 and below 5mm).
Test	- Test for every 300 tons of recycled aggregate produced (density, water absorption, ten percent fine, chloride, sulphate, flakiness, elongation). - The Central Government Laboratory is conducting tests on durability.
Cost	- Operation cost is about HK$40/tons (including test, management and labour). - Capital cost of the plant is about HK$25,000,000
Suggestions	- Landfill charging scheme will encourage contractors to sort the waste that will facilitate operations of the recycling plant at Tuen Mun. - Recycling plants need to be scattered over the territory, providing such facilities at convenient locations such as besides each public filling area and by reducing the scale of each plant to serve the needs of each individual district.

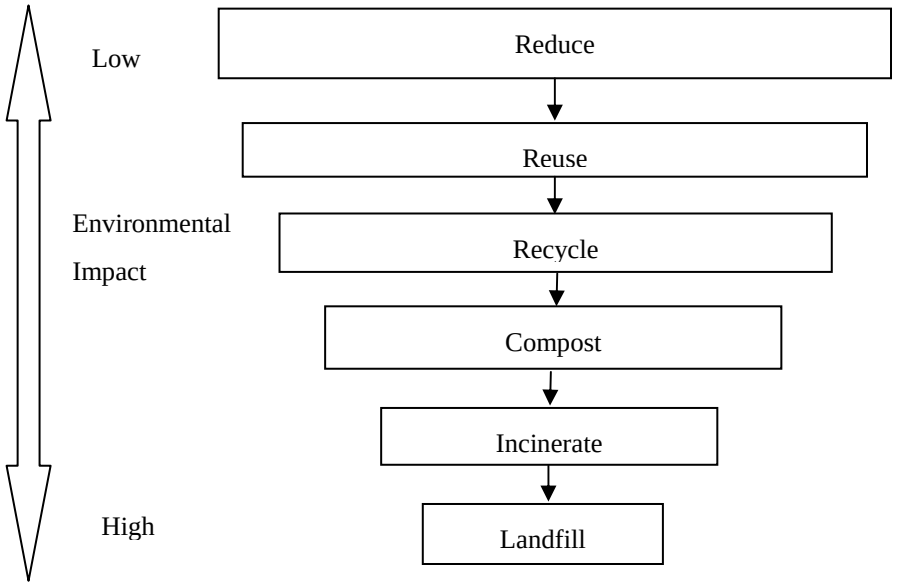

Figure 1: Hierarchy of Construction and Demolition Waste [1]