Executive Summary

Hong Kong is running out of both reclamation sites and landfill space for the disposal of Construction & Demolition (C&D) Waste. It is important for Hong Kong to adopt a strategy to reduce, reuse and recycle C&D waste and handle it in a more environmentally responsible manner. Reduction at source coupled with good civil engineering project planning and execution for reusing the inert portion of C&D waste will have positive effect on the sustainable development of Hong Kong. Recycled aggregates have been demonstrated to be able to produce quality concrete for structural application and other engineering uses. Establishing the market for recycled C&D products and setting up of C&D materials recycling facility in strategic locations in Hong Kong will help but a number of hurdles, both technical and administrative, have to be overcome. This paper will discuss the problem, analysis the current situation and make suggestions to promote a viable market for recycled C&D aggregates.

1. Introduction

The construction industry of Hong Kong has generated over 10 million tonnes of construction waste each year. Although apparently there has been reduction in generation in 2005 to 2007 due to economic downturn (Figure 2), the generation has increased from 2007 and is expected to continue as more mega-projects like the express rail, the Hong Kong-Zuhai-Macau Bridge, the cruise terminal and development of the West Kowloon Culture District are rolling out in the next few years. In the past, the inert portion of the construction waste such as rock, concrete and soil has been used as fill materials for reclamation and formation of lands for development. However, with the increasing sentiment against reclamation projects, many planned reclamations projects are delayed or reduced in size or even held in abeyance. Hong Kong can no longer solely rely on location reclamation to resolve the accommodation of the surplus inert construction waste. To ensure sustainable development of Hong Kong, there is a need to manage the construction waste systematically and maximize their utilisation.
Methods include the implementation of waste management plan, reducing the generation at source, charging on disposal of construction waste, recycling of inert hard construction waste and reuse of inert construction waste in local reclamation works and also beneficial reuse of construction waste as fill in reclamation in Mainland China.

2. **Construction and Demolition (C&D) Materials**

C&D materials means any substance, matter or thing which is generated as a result of construction work and abandoned whether or not it has been processed or stockpiled before being abandoned. It is a mixture of surplus materials arising from site clearance, excavation, construction, refurbishment, renovation, demolition and road works.

Over 80% of C&D materials are inert and are known as public fill. Public fill includes debris, rubble, earth and concrete which is suitable for land reclamation and can be used as filling material for site formation. When properly sorted, materials such as concrete and asphalt can be recycled for use in construction. The remaining non-inert substances are known as C&D wastes which include bamboo, timber, vegetation, packing waste and other organic materials. In contrast to public fill, non-inert waste is not suitable for land reclamation and subject to recovery of reusable or recyclable items, is disposed of at landfills. Figure 1 shows the typical composition of C&D materials in Hong Kong.

![Figure 1 Typical Composition of C&D Materials](image-url)
3. Challenges

In the old days, when the materials were scare and expensive in comparison to labour costs, lots of these C&D materials had been salvaged and reused through balance cut and fill, rehabilitation, reclamation, reuse of brick and masonry, reuse of timber and wood to its maximum potential. With the prosperity and rapid development of Hong Kong, the society has become more and more extravagant and less concern on conservation of natural resources. The following factors contributes to the current situation:

- Lower cost in exploiting natural resources due to invention of modern machineries;
- Low import cost of aggregates from neighbouring developing regions including Mainland China;
- Demolition of buildings and structures long before the end of their designed and useful life for redevelopment to high rise buildings when the height restriction in urban area is removed after relocation of the airport;
- Inherited bad “use and throw away” habit;
- Fast development programme for quick financial return; and
- Poor or lack of waste management concept.

As a result, lots of natural resources were drained away as waste and required extra expense and resources to handle and accommodate. Worst still, it will not only create environmental and social problems, the society will consume the remaining natural resources at a much faster rate than is necessary, thus jeopardising the well-being of our next generation. There is a need for proper waste management for the sustainable development.

For the C&D wastes, they are disposed of at municipal solid waste landfills. It can be observed from Figure 2 that the disposal of construction waste to municipal landfills is gradually decreasing and major portion is being disposed of at public fill reception facilities for later use in reclamation.
In the past, public fill were used as filling material in reclamation. Reclamations have been widely used to form lands to cope with the on-going development in Hong Kong. These reclamations have provided an outlet to accommodate huge volume of public fill generated from the local construction activities. However, the recent public sentiment against reclamation projects has caused many planned reclamation projects to be delayed, reduced in size or even held in abeyance. Reclamation is no longer regarded a reliable option for accommodating surplus public fill.

Table 1 shows the cumulative reclamation areas in Hong Kong since the mid-19th century. It is noted that substantial reclamations were taken place during 70s to 90s when the satellite towns at Tuen Mun, Shatin, Tai Po, etc. were being developed followed by Airport Core Projects being carried out in full speed. After the judgement made by the Court of Final Appeal on the Protection of Harbour Ordinance in early 2004, the total area of completed reclamation has substantially reduced and has nearly come to a halt in recent years except the remaining on-going reclamation project for the construction of the Central to Wanchai Bypass.
<table>
<thead>
<tr>
<th>Year</th>
<th>Cumulative Reclaimed Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1887</td>
<td>159</td>
</tr>
<tr>
<td>1888 to 1924</td>
<td>581</td>
</tr>
<tr>
<td>1925 to 1945</td>
<td>780</td>
</tr>
<tr>
<td>1946 to 1967</td>
<td>1,486</td>
</tr>
<tr>
<td>1968 to 1976</td>
<td>1,772</td>
</tr>
<tr>
<td>1977 to 1996</td>
<td>6,067</td>
</tr>
<tr>
<td>1997 to 2004</td>
<td>6,802</td>
</tr>
<tr>
<td>2005 to 2010</td>
<td>6,823</td>
</tr>
</tbody>
</table>

**Table 1  Cumulative Reclaimed Area in Hong Kong**

In view of depletion of reclamation projects to receive public fill, a holistic waste management strategy is need for C&D materials management to alleviate the demand for disposal sites.

### 4. Management Strategy for Construction Waste

In view of limited capacity for further reclamation and the sustainable development of Hong Kong, the Government of Hong Kong Special Administrative Region (the Government) has implemented waste management strategy in both public works projects and promoted the same in private projects. The strategy is indicated in Figure 3 in the order of desirability which includes:

- Avoid and Minimizing the generation of construction waste at source;
- Reusing the construction waste in its original form as far as possible;
- Recycling with minimal input of energy;
- Disposing of the construction waste in environmental friendly manner, with non-inert waste to landfills.

**Figure 3 Management Strategy for Construction Waste**

The strategy also aims at achieving three objectives (i) to reduce the generation of construction waste, (ii) to maximise reuse and recycling and (iii) to reduce the intake of mixed construction waste at landfills. The essence is to:

- Maintain a well-managed public filling programme with sufficient public fill reception facilities and barging points at convenient locations;
- Encourage sorting, preferably on site sorting, of mixed construction waste;
- Encourage reuse and recycling of construction waste;
- Avoid and minimise construction waste through better design and construction management; and
- Introduce construction waste disposal charging scheme as an economic incentive to encourage waste reduction.
5. **Facilities for Handling Construction Waste**

5.1 **Public Fill Reception Facilities**

Public filling areas, public filling barging points, public fill stockpiling areas, fill banks and C&D material recycling facility are collectively regarded as public fill reception facilities and are managed by the Civil Engineering and Development Department to accept public fill. Each facility has its own function.

Public filling area (Figure 4) is a designated part of a development project that accepts public fill for reclamation purpose. Public fill stockpiling area is a newly reclaimed land where public fill is stockpiled as surcharging material to accelerate the settlement process. After they have achieved the required settlement, the public fill will be removed and deposited in other reclamation. As I mentioned earlier, these filling areas/stockpiling areas have been depleted either due to public sentiment against reclamation or due to ecological reasons such as protection of breeding ground for wild life including Chinese White Dolphins and Finless Porpoise and feeding grounds for birds including White-bellied Eagle.

![Figure 4 Penny's Bay Reclamation Phase II as Public Filling Area](image)

Public filling barging point is a strategically located public fill reception facility that utilizes barge transportation to transfer public fill. Fill bank (Figures 5 & 6) is an area allocated for temporary stockpile of public fill for later use.
C&D Recycling facility (Figure 7) processes hard inert materials into recycled aggregates and granular materials for use in construction activities.

5.2 Construction Waste Sorting Facilities

Mixed construction waste containing more than 50% by weight of inert
construction waste can be delivered to the sorting facilities (Figures 8 & 9). Public fill recovered will be disposed of at fill bank while non-inert construction waste will be disposed of at landfills. This arrangement helps waste producers, particularly small construction sites that do not have enough space to carry out on-site sorting.

![Sorting Facility at Tseung Kwan O](image1)

**Figure 8  Sorting Facility at Tseung Kwan O**

![Sorting Facility at Tuen Mun](image2)

**Figure 9  Sorting Facility at Tuen Mun**

### 5.3 Landfills

Mixed construction waste containing not more than 50% by weight of inert construction waste can be disposed of at the three strategic landfills, viz. the West New Territories (WENT) Landfill (Figure 10), the South East New Territories (SENT) Landfill (Figure 11) and the North East New Territories (NENT) Landfill (Figure 12) which are managed by the Environmental Protection Department.
Figure 10  West New Territories (WENT) Landfill

Figure 11  South East New Territories (SENT) Landfill

Figure 12  North East New Territories (NENT) Landfill
5.4 Outlying Islands Transfer Facilities

There are seven outlying islands transfer facilities in Mui Wo, Peng Chau, Hei Ling Chau, Cheung Chau, Yung Shue Wan, Sok Kwu Wan and Ma Wan for delivering construction waste to West New Territories Landfill by container vessels. Figure 13 shows the locations of all facilities for handling construction waste in Hong Kong.

Figure 13 Facilities for Handling Construction Waste in Hong Kong

6. Reduction

Space for accommodation of construction waste is not unlimited. Every effort should be made to avoid and minimize the generation of construction waste at source. Minimization of waste should commence at the onset of the project. This includes better planning layout, balanced cut and fill, use of precast construction, reuse and recycling of construction waste on site with minimal import and export.

6.1 C&D Management Plan and Waste Management Plan

In order to manage the inert construction waste, i.e. public fill, the Government has set up a Public Fill Committee (PFC) to implement measures to promote avoidance, minimization, reuse and recycling of
inert construction waste, and to oversee the management of public filling operation and facilities and the use of land-based fill reserves. All public works projects are required to implement waste management, with proper presorting on site to separate construction wastes into severable categories for proper disposal to the appropriate disposal facilities and recyclable materials to the recycler for processing.

Government project offices in the planning and design should actively seek to minimize C&D material generation and to reuse inert material generated including rock, as far as possible. To achieve this, the project office is required to draw up a Construction and Demolition Materials Management Plan (C&DMMP) at the feasibility study or preliminary design stage for each project, which generates more than 50,000 m$^3$ of C&D material including rock or that requiring imported fill in excess of 50,000 m$^3$. Projects generating C&D material less than 50,000 m$^3$ or importing fill material less than 50,000 m$^3$ are exempt from the C&DMMP. However, the project office should establish a system similar to the C&DMMP in order to minimise C&D material generation.

For projects classified as "designated" projects under Schedule 2 of the Environmental Impact Assessment Ordinance (EIAO), the C&DMMP should be submitted together with the Environmental Impact Assessment (EIA) report to PFC for approval. For projects which are not classified as "designated" projects under Schedule 2 of the EIAO but generating surplus C&D material in excess of 300,000 m$^3$ or requiring imported fill exceeding 300,000 m$^3$, the C&DMMP should be submitted to PFC for in-principle approval prior to commencement of the detailed design.

When the public works project goes on to the construction stage, the contractor shall prepare a Waste Management Plan (WMP). The WMP provides an overall framework for waste management and reduction. It identifies major waste types and defines ways for waste reduction. An appropriate WMP should contain:

- Key types of waste to be reduced (e.g. waste that are hazardous to the environment, bulky, valuable, reusable or recyclable would obtain higher priority for reduction);
- Waste reduction targets (i.e. waste reduction targets such as
percentage reduction and recycling rate would be set out)

- Waste reduction programmes (i.e. actions for waste reduction would be worked out for each identified waste type in the form of waste reduction programmes, procedures and guidelines)

- Waste disposal procedures (i.e. proper waste disposal procedures would be defined for each waste type)

- Monitoring and Audit (i.e. monitoring programme would be set up to record the quantity of waste generated/ reduced/ recycled/ disposed as well as other performance indicators in the WMP. Review the performance of the WMP and update the plan whenever necessary)

### 6.2 Low Waste Construction Designs and Technologies

Several kinds of design and technologies help to reduce the amount of C&D materials to be generated.

Adoption of lean construction such as using thinner internal walls and floor slabs and reducing foundation size could minimise the amount of raw material being used and thus reduce the amount of waste.

For foundation works and earth projects, design for reusing excavated spoils as back-fill material to balance cut and fill could reduce the generation of excavated spoils. If cut and fill could not be balanced on-site, possible exchange with other sites should be sought. Such matching of surplus excavated material and deficit of fill material are being assisted by the information provided by Fill Management Division of the Civil Engineering and Development Department.

Modular building designs and standardized cell layout enhance precasting of building components such as facades, staircases and semi-precast floor slabs. Off-site prefabrication can reduce cut-off wastage and the use of moulds on-site. Besides, factory controlled processes are more reliable, and can use more sophisticated techniques and fittings of which the net amount of materials employed can be reduced.

Construction designs should be flexible to include opportunities for future adaptation of buildings. Reuse of construction waste such as bricks and tiles, use of recycled materials in new construction such as
reused aggregates and asphalt, and use of pulverized fuel ash and durable and recyclable materials such as metals instead of timber should also be encouraged.

6.3 Raw Material Management

Too early an order or over-ordering together with poor storage and maintenance of raw materials always result in deterioration and damages. To avoid accumulation, the right amount of raw materials should be ordered at the right time with proper control and documentation on material flow.

Mishandling of raw materials and improper operation procedures are often causes for high raw material wastage. Raw materials should be fully utilized to avoid wastage. As such, current operation procedures should be reviewed to include any waste reduction measure, while raw materials should be carefully used, especially during installation and cutting. Besides, broken items or offcuts should be considered for sections when small lengths are required.

6.4 Waste Disposal Charging Scheme

The introduction of Construction Waste Disposal Charging Scheme (the Charging Scheme) in December 2005 further promotes the minimization of the generation of construction waste at source by the construction industry. Since December 2005, the Government has implemented Construction Waste Disposal Charging Scheme and introduced charging for the disposal of construction waste at the Public Fill Reception Facilities, Construction Waste Sorting Facilities, Landfill and Outlying Island Transfer Facilities operated by the Government through the amendments of Waste Disposal Ordinance (Chapter 354).

The aim of the Scheme is to promote the reduction of construction waste at source, encourage selective demolition and on-site sorting and recycling by financial incentive. Unsorted/poorly sorted waste will be charged at higher rates as compared to well.sorted inert construction waste.

The Charging Scheme has come into operation on 1 December 2005. Starting from 1 December 2005, main contractor who undertakes construction work under a contract with value of $1 million or above is required to approach the Environmental Protection Department and to
open a billing account solely for the contract. Application shall be made within 21 days after the contract is awarded. Failing this will be an offence under the law. For construction work under a contract with value less than $1 million, such as minor construction or renovation work, any person such as the owner of the premises where the construction work takes place can open a billing account. The premises owner concerned may also engage a contractor with a valid billing account to make arrangement for disposal of construction waste. The contractor’s account can also be used for contracts each with value less than $1 million.

The effective rates for disposal of waste at different disposal facilities are shown in Table 2.

<table>
<thead>
<tr>
<th>Government Waste Disposal Facilities</th>
<th>Type of Construction Waste Accepted</th>
<th>Charge per tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public fill reception facilities#</td>
<td>Consisting entirely of inert construction waste</td>
<td>$27</td>
</tr>
<tr>
<td>Sorting facilities#</td>
<td>Containing more than 50% by weight of inert construction waste</td>
<td>$100</td>
</tr>
<tr>
<td>Landfills@</td>
<td>Containing not more than 50% by weight of inert construction waste</td>
<td>$125</td>
</tr>
<tr>
<td>Outlying Islands Transfer Facilities@</td>
<td>Containing any percentage of inert construction waste</td>
<td>$125</td>
</tr>
</tbody>
</table>

# operated by CEDD  @ operated by EPD

**Table 2 Rates for Disposal of Waste at Different Disposal Facilities**

Prior to the implementation of the Charging Scheme, fill materials were often mixed with construction wastes because there was no or minimal sorting done by the construction industry. The fill materials mixed with construction wastes were dumped at landfills for disposal, rendering it wastage of useful materials as well as consuming the precious landfill space which are primarily designed for the disposal of
municipal solid waste.

There are positive effects arising from the implementation of the Charging Scheme. Compared with the pre-charging figures, the amount of construction wastes directly disposed of at landfills were reduced by 85% as at end 2009, while the overall disposal of construction waste was reduced by about 19% over the same period. Details of the Charging Scheme are shown in Table 3. The Charging Scheme has helped to encourage the construction industry to minimize generation of all types of C&D materials in the long run.

<table>
<thead>
<tr>
<th>Year</th>
<th>2005*</th>
<th>2006*</th>
<th>2007*</th>
<th>2008*</th>
<th>2009*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disposed of at Landfills (Mt)</td>
<td>2.400</td>
<td>0.410Å$</td>
<td>0.390Å</td>
<td>0.370Å</td>
<td>0.360Å</td>
</tr>
<tr>
<td>Handled by Sorting Facilities (Mt)</td>
<td>N.A.</td>
<td>1.462</td>
<td>0.893</td>
<td>0.763</td>
<td>0.748</td>
</tr>
<tr>
<td>Handled by Public Fill Reception Facilities (Mt)</td>
<td>7.400</td>
<td>6.070Å</td>
<td>6.420Å</td>
<td>6.820Å</td>
<td>6.820Å</td>
</tr>
<tr>
<td>Total (Mt)</td>
<td>9.800</td>
<td>7.942</td>
<td>7.703</td>
<td>7.953</td>
<td>7.928</td>
</tr>
<tr>
<td>Reduction compared with 2005 (% approximately)</td>
<td>-</td>
<td>19</td>
<td>21</td>
<td>19</td>
<td>19</td>
</tr>
</tbody>
</table>

* Before Charging Scheme      # After Charging Scheme
Å Excluding sorted construction waste from two sorting facilities
$ Covering the period 20 January 2006 to 31 December 2006 (as charging for disposal of construction waste and fill materials (or “construction waste and fill materials” can be changed to “C&D materials”) commenced on 20 January 2006

Table 3  Construction Wastes Handled by Different Facilities

### 6.5 Selective Demolition & On Site Sorting

Selective Demolition involves sequencing the demolition activities to allow the separation and sorting of building materials. In general, domestic wastes such as furniture, household appliances, etc., metal components such as window frames, pipes, etc., timber component such as doors, wooden floors, etc., other wastes such as tiles, asphaltic materials, ceramic products should be removed one by one first.

The main demolition shall begin after all the above non-structural
materials have been stripped and removed. As most old building blocks are built with brick walls on concrete frames, the percentage of brick is extremely high, ranging from 60% to 80%. To avoid mixing the non-recyclable bricks and tiles with the broken concrete, it is highly recommended to plan the demolition sequence such that brick walls are demolished first and stockpiled separately before the demolition of structural members.

Without the implementation of selective demolition, all types of demolished materials will be mixed together. As a good practice, they should be sorted on-site and be separated into different groups including broken concrete, rock, bricks, rubbles, asphalt, soft inert material and non-inert waste. Sorted materials should be delivered to the recycling facilities as far as possible.

7. Reuse

The mandatory implementation of C&D Management Plan in public works project has caused project proponents to use surplus fill materials as far as practicable. For instance, surplus fill materials have been used for the following reclamation projects:

- Tseung Kwan O Area 137 Reclamation;
- Tung Chung Development Phase 3A Reclamation;
- Pak Shek Kok Reclamation;
- Jordon Road Reclamation Phase III;
- Penny’s Bay Reclamation Stage II;
- Tseung Kwan O Town Centre Reclamation Phase III Stage II;
- North Tsing Yi Reclamation;
- Tuen Mun Area 38 Reclamation;
- Central Reclamation Phase III; and
- Wan Chai Development Phase II.

Fill materials reuse strategy in designing projects in the pipeline that would involve reclamation, such as the proposed Hong
Kong-Zhuhai-Macao Bridge (HZMB) Hong Kong Boundary Crossing Facility (HKBCP), the HZMB Hong Kong Link Road, and the Tuen Mun-Chek Lap Kok Link projects. Through the design of engineering method, the use of surplus fill materials for the reclamation has been maximized while the use of marine sand fill is minimized as far as possible.

The Government has also been keeping in view the planning status of all public works project proposals which can have the capacity to absorb surplus public fill, so that forward planning on their fill demand can be factored in the strategic management of fill materials to ensure reuse of public fill as far as possible.

7.1 Public Fill Reception Facilities (PFRF)

The Government has set up two fill banks in Tseung Kwan O Area 137 and Tuen Mun Area 38 in 2002 and 2003 respectively for temporary stockpiling of surplus fill materials for later beneficial reuse. Stockpiling without a subsequent outlet is not a genuine solution, and in any case it is very difficult to identify new sites to serve as land intensive fill banks due to shortage of land in the territory.

7.2 Construction Waste Sorting Facility

The Government also set up C&D materials sorting facilities in Tseung Kwan O Area 137 and Tuen Mun Area 38 respectively. Mixed C&D materials containing more than 50% by weight of inert materials can be delivered to the sorting facilities and the sorted inert fill materials will be stored in the fill banks for later beneficial reuse, whereas only the remaining non-inert materials will be disposed of in landfills.

7.3 Reusing Surplus Public Fill in Reclamation in the Mainland

Owing to the running down of reclamation projects in Hong Kong in recent years, the surplus public fill problem has reached an acute stage where available reclamation projects are unable to accommodate all public fill. The Government has been relying on the fill banks to provide temporary storage for the fill material.

To tackle the problem of surplus public fill, the Government has explored opportunities to deliver the surplus fill to the Mainland for beneficial reuse in reclamation projects. Cooperation Agreement
between the State Oceanic Administration (SOA) and the Government was signed in March 2004. This provides a foundation for the accommodation of public fill in Mainland waters. The Government reached an agreement with the South China Sea Branch of the State Oceanic Administration (SOA(SCSB)) in June 2005 on the implementation details to ensure that the use of public fill in reclamation projects will not cause any environmental problems. The details include material specifications, delivery requirements, inspection and control measures.

In January 2006, SOA(SCSB) designated a trial reclamation in Guang Hoi Wan (廣海灣) of Taisha (台山) to receive public fill from Hong Kong. In November 2006, a contract for the cross-boundary delivery of surplus public fill to a reclamation site in Taishan was awarded. The delivery of public fill to Taishan commenced in July 2007 and about 23 million tonnes of public fill has been delivered up to end December 2009.

The scheme has demonstrated that the delivery of surplus public fill to the Mainland is an environmentally sound and mutually beneficial arrangement in dealing with the huge volume of public fill. In particular, the delivery arrangement has helped alleviate Government’s pressure in accommodating surplus public fill, in the absence of which the fill banks would have been filled up and any surplus public fill would have to be disposed of at the fast depleting landfills. Furthermore, the delivery arrangement has enabled the public fill to be put into beneficial reuse in the Mainland. It is consistent with the principles of environmental protection and sustainable development and is a win-win solution for both Hong Kong and the Mainland.

As the delivery scheme involves cross-boundary delivery of public fill, the contractor has to comply with the laws and regulations in Mainland as well as those in Hong Kong. The dumping of public fill in Mainland is controlled by the Marine Environmental Protection Law of the People’s Republic of China and Regulations on Control over Dumping of Wastes in the Ocean. In Hong Kong, Dumping at Sea Ordinance (DASO, Cap. 466) controls the dumping of substances and articles from vessels, aircrafts, and marine structures in the sea and under the sea-bed and the related loading operations in accordance with the spirit of the Convention on the Prevention of Marine Pollution by Dumping of
Wastes and Other Matters (the London Convention). The contractor for transporting public fill to the Mainland is responsible for the application of the permits from SOA under the Marine Environmental Protection Law and EPD under the DASO. Transportation of materials to Mainland can only commence after obtaining the appropriate permits both the Mainland and Hong Kong authorities.

8. Recycle

In addition to environmental protection, conservation of natural aggregate resources, shortage of waste disposal land, and increasing cost of waste treatment are the principal factors for recycling of demolition waste in the construction industry in Hong Kong. In 2009, the amount of municipal solid waste was 6.45 million tonnes with 3.27 million tonnes being disposed of in landfills (Figure 14).

![Figure 14](image-url)

**Figure 14  Quantity of Municipal Solid Waste Disposed of and Recovered in 1991-2009**

As shown in Figure 2, the construction industry produced about 15.4 million tonnes of C&D materials in 2009 of which substantial portion of 14.3 million tonnes were stockpiled in fill banks. The total amount of construction waste was 2.4 times of the municipal solid waste in the same period. Among the inert construction waste, i.e. the portion stockpiled in fill banks, the concrete and masonry rubble has the largest proportion and hence its recycling is the most important.
Many laboratory and field studies have shown that the size fraction of the concrete and masonry rubble corresponding to coarse aggregate can be satisfactorily used as substitute for natural aggregate in concrete and pavement. Similarly, such aggregates can be safely used as a sub-base or base layer in pavements.

The construction industry in Hong Kong consumes on average about 21 million tonnes aggregates each year. A large proportion, about 88%, is used as aggregate in the production of concrete. Asphalt production consumes around 5.5% and the remaining 6.5% is used in pavement sub-bases and other civil engineering works. It is estimated that each year about 2.3 million tonnes of recycled aggregate can be produced from the recyclable construction waste, out of which about 1.2 million tonnes could be utilized as pavement sub-bases, trench backfilling material and drainage fill, etc. This left around 1.1 million tonnes of recycled aggregates which should be utilized in the production of concrete. As such, the Government has explored various possible applications of recycled aggregates in Hong Kong with emphasis on the use of recycled aggregates which have been identified as an integrated approach to overcome surplus public fill problem in Hong Kong.

8.1 Establishment of Temporary Recycling Facility

In mid-July 2002, the Government commissioned a pilot C&D material recycling facility in Turn Mun Area 38 to produce recycled C&D products for use in Government projects and research and development works. The facility was established in the Tuen Mun Area 38 Stage 2 reclamation site to take the advantage of convenient supply of inert hard C&D materials. It has a designed output capacity of 1,200 tonnes per day to produce ranges of recycled aggregates and granular materials for various potential uses.
8.2 Recycling Process

The recycling facility is basically consisted of a primary sorting facility (grizzly), crushers (primary and/or secondary), impurity removal facilities (manual sorting facility, magnetic ferrous metal separator and air knife), vibrating sieves and stockpiles as shown in Figure 16.
The incoming inert C&D materials are initially directed to a vibrating grizzly for preliminary sorting to sort out suitable hard inert materials for recycling. Hydraulic crusher and pneumatic breaker will be employed to break down the materials to a size suitable for primary crushing, with reinforcement removed.

After preliminary sorting, the recyclable materials are fed into the primary crusher for primary crushing to 200mm down size, which is suitable for secondary crushing, by the jaw movement of the crusher. The recyclable materials from the jaw crusher will then be gone through a series of impurity removal processes before feeding into the cone crusher for secondary crushing. In this process, the metal, dirt, plastic, timber, paper and highly disposed rocks, etc. will be removed. Afterwards, the cleaned recyclable materials will then be crushed to less than 40mm size and sieved into different sizes\(^1\) of recycled aggregate products for stockpiling in storage compartments.

### 8.3 Possible Applications of Recycled Aggregates

There are a lot of potential applications of recycled aggregates and granular materials, including, but not limited to:

- Concrete production\(^2\);
- Granular materials for fill, filters, drainage layer, etc.;
- Road sub-base materials;
- Concrete paving blocks or similar block works;
- Rockfill replacement for seawall, infill to gabion walls, etc.

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\(^1\) Different sizes of 40mm, 20mm, 10mm and 5mm down

\(^2\) The Standing Committee of Concrete Technology of the Government recommends that recycled aggregates can be used for concrete production up to Grade 35 until further tests have demonstrated that concrete with higher strength can be consistently produced with satisfactory performance in long-term durability
Figure 17  Applications of Recycled Aggregates in Construction Works

8.4  Hong Kong Experience in the Use of Recycled Aggregates

Hong Kong Wetland Park is located at the north-western part of Hong Kong and is close to the border between Hong Kong and Shenzhen of the Mainland. The project was completed in 2005. In the project, recycled aggregate was employed to replace part of the virgin aggregate in the majority of the structural concrete. The highest concrete grade used is 35MPa. A total volume of about 5,000m$^3$ of ready mixed concrete using recycled aggregates has been placed.

Based on the specifications, the replacement levels of recycled coarse aggregate were 100% and 20% for concrete grade C20, i.e. 20MPa, or below and C25 to C35 respectively. More research and development work are on-going to promote the use of recycled aggregates in Hong Kong. This includes studies on the production of precast bricks and blocks, the influence of initial moisture states of recycled aggregates on the properties of concrete produced, the use of Pulverised Fuel Ash, and the production of C45 recycled aggregate concrete.
8.5 Barriers in the Use of Recycled Aggregates

From an economical point of view, recycling of construction waste is only attractive when the recycled product is competitive with natural resources in relation to cost and quality. Recycled materials will normally be competitive where there is a shortage of both raw materials and suitable deposit sites. Since rock is widely available in the Mainland China, the price of crushed rock is cheaper than recycled aggregates. However, the capacity of landfills and public fills is at alarming stage. Differential charging for waste disposal has been in place to encourage the construction and demolition contractors to pay the recycling industry for delivering the construction waste to the sorting plant or do their own sorting on site. Another possible option is to force the construction industry to use a special percent of recycled products in their development project through legislation. As a result, the construction industry is subsidizing the recycling industry through mandatory use of recycled products even these products are more expensive.

The supply of recycled aggregates is sporadic, and depends on a number of factors, including volume and type of construction and demolition activities and the recycling infrastructure. Since the production of recycled aggregates is not profitable, it can only rely on the Government to provide the required recycling infrastructure.

Although research works had indicated that recycled aggregate could be used for production of concrete, it is generally perceived by practicing engineers that recycled aggregates are inferior to natural aggregates. It will take some time to demonstrate to the professionals in construction industry that the quality of recycled aggregates is comparable to that of natural aggregates.

8.6 Ways to Promote the Use of Recycled Aggregates

Opportunities should be searched in the precast industry about the use of recycled aggregates as it is easier to ensure quality in such products due to the presence of an existing quality assurance system. Precast industry can blend a small portion of recycled aggregates with natural aggregates through research studies. Such trial can be implemented with proper coordination of industries and Government departments. The target products can be partitioning walls, road dividers, bridge
fencing, noise barriers, paving blocks, etc., which do not require very high quality standards.

Appropriate changes in legislation should be made about the use of recycled products particularly in the Government projects. The new legislation should bind the contractors/consultants to use a suitable portion of recycled products in their projects.

A quality assurance system should be developed to assure the quality of recycled products. Quality assuring certificates should be issued by independent certifying institutions if the requirements for the installation, the production process, the quality-check and the finished product of the recycled aggregate producers, all comply with the quality requirements. This can promote the image of recycled aggregates and enhance its competitiveness.

9. Conclusion

The success of management of construction waste relies on the co-operation amongst all stakeholders, including the Government, the society, town planner, developers, designers, the contractors and the waste haulers. As landfill space is not unlimited, every effort should be made to reduce the generation of construction waste, extend the potential use of surplus waste and minimize the need for disposal at landfill so that Hong Kong's development can be sustainable. The reuse of recycled materials derived from construction and demolition waste is growing all over the world. Hong Kong Government is actively promoting policies aimed at reducing the use of primary resources and increasing reuse and recycling. One of the most environmentally responsible ways of meeting the challenges of sustainability in construction is the use of recycled concrete or masonry waste as aggregate in new construction.
Reference

Civil Engineering and Services Department, *Environment and Sustainability Services*, April 2010

Civil Engineering and Services Department, *Guidelines for Selective Demolition & On Site Sorting*, July 2004


Fong, F.K., Ng, K.C., “Recycling of Construction and Demolition Materials in Hong Kong”, *Proceedings of 2nd Symposium on Sustainable Development of Guangdong, Hong Kong and Macau – Strategic Partnership in the Pearl River Delta*, jointly organised by HKIE, Guangdong Provincial Association for Science and Technology, and the Macau Institution of Engineers, April 2003

Fong, F.K., Yeung, S.K., “Production and Application of Recycled Aggregates”, *Proceedings of Green Buildings*


Nadeen, A., Mok, Y.N., Leung, W., Azhar, S., “The Application of Recycled Aggregate for the Urban Sustainability of Hong Kong Construction Industry

