

EXPO 2019

CONSTRUCTION INNOVATION

2019 建造創新博覽會



Innovative Materials for Greener City

創新材料 · 構建綠色城市



發展局
Development Bureau



CONSTRUCTION
INDUSTRY COUNCIL
建造業議會



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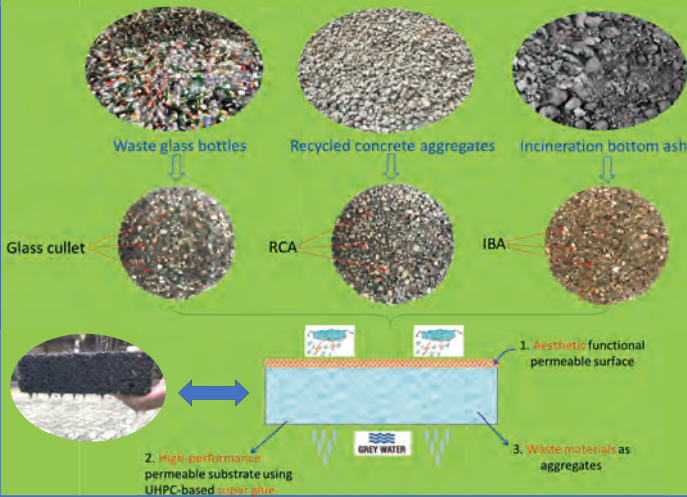


High-Performance Eco-Permeable Concrete Prepared with Waste Materials

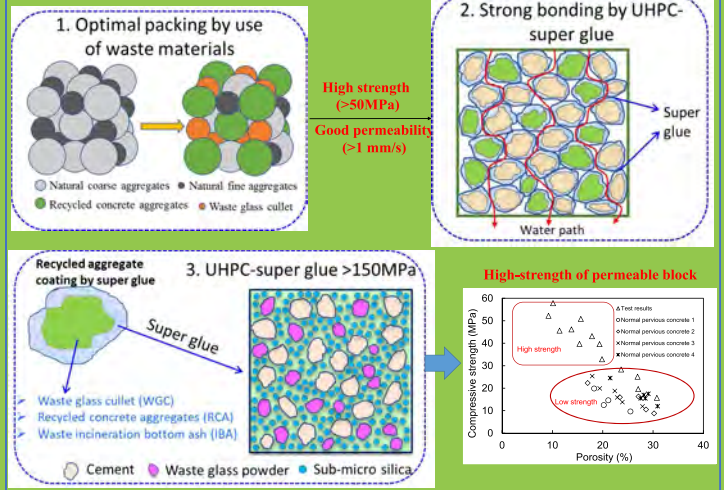
Eco-Permeable Concrete consists of **an aesthetic-functional permeable surface, a high-performance permeable substrate and an ultra-high performance cement (UHPC)-based super glue.**

1. Design

Recycling of Waste Materials in Eco-Permeable Concrete

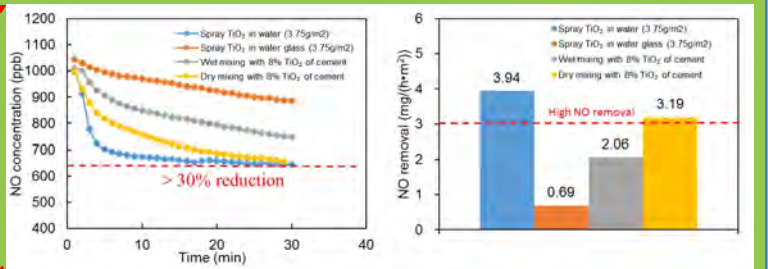
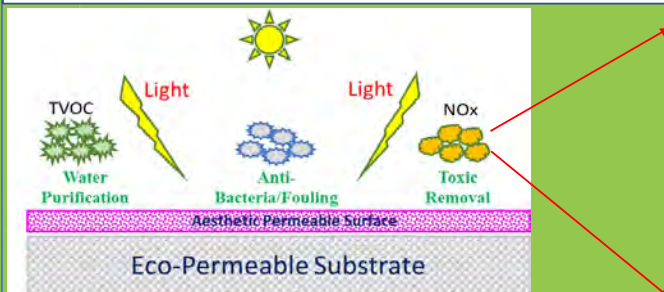


Characteristics of preparation



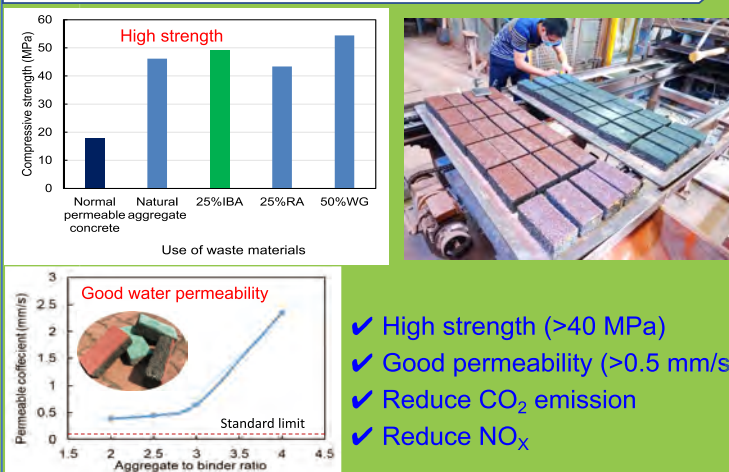
2. Aesthetic-Functional Properties

Environmental functions: air purification



3. Properties and Industrial production

4. Application



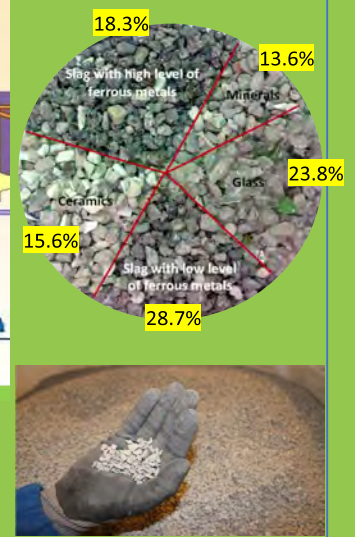
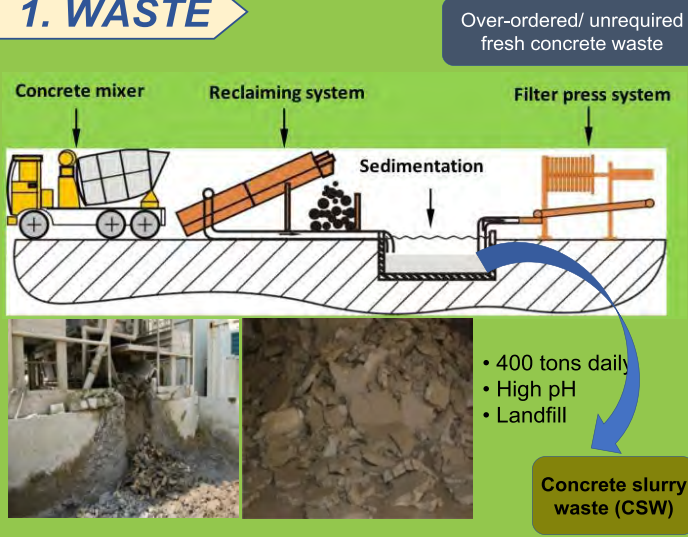
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Cementless production of lightweight aggregates from Incineration Bottom Ash (IBA) and Concrete Slurry Waste (CSW)

valorizing waste materials using pelletization technique into **cold-bonded lightweight aggregates (CBLA)** incorporating **incineration bottom ash (IBA)** and **concrete slurry waste (CSW)**

1. WASTE

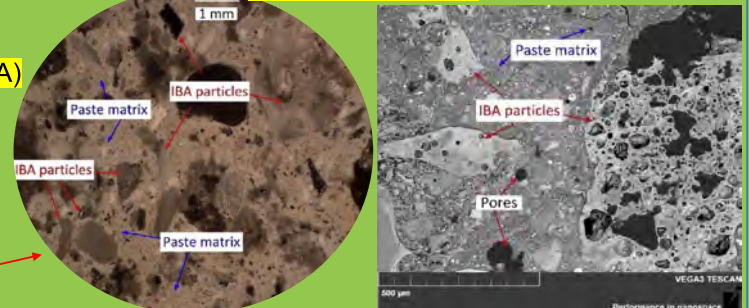


1. WASTE 2. PELLETIZATION

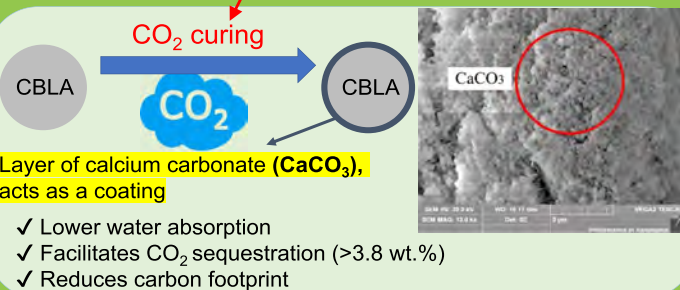
Production of cold-bonded lightweight aggregates (CBLA)



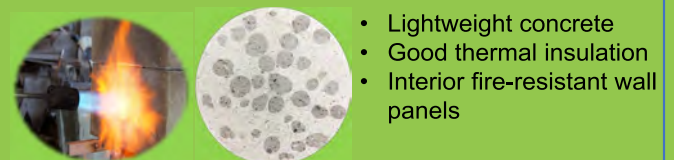
Optical and SEM-BSE images



	Binders	Pellet strength (Mpa)	Crushing resistance (Mpa)	Loose bulk density (g/cm ³)	Water absorption (%)
CSW+IBA	0	1.08	5.9	888	19
CSW+IBA	10% OPC	2.34	8.2	868	22
CSW+IBA	10% GGBS	1.95	7.9	865	19
Milled IBA	10%~30% OPC	*	2.5~4.5	1150~1320	11~13
Quarry fines	10%~30% OPC	0.05~0.32	*		
Quarry fines	30%~50% waste ashes + carbonation	0.13~0.17	*	850~920	26~27.8



1. WASTE 2. PELLETIZATION 3. APPLICATION



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Maximize the recycling of waste glass

Jian-xin LU, Chi Sun Poon*

The situation of waste glass in HK:




Waste glass has become an important part in the municipal solid waste (MSW) stream. Due to its low commercial values and the lack of glass manufacturing industry in Hong Kong, the recovery rate of waste glass is **less than 10%**. For this reason, it is very important to develop viable recycling technologies to recycle more waste glass.




Hong Kong (2017)

Waste glass containers	291 tonnes daily
Recovery rate	Less than 10%
Reason	No glass manufacturing industry
Management	Mostly landfilled






✓ **Glass action:** Good aesthetic property of glass → recycle waste glass to produce architectural products.


Glass wastes



Different colour glass cullet




Mix glass cullet (as fine aggregates)



Waste glass powder (as SCM)




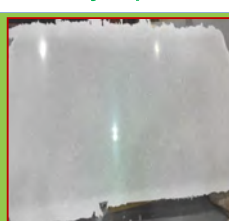

Production of waste glass powder




Maximize the use of the waste glass in architectural mortar

- ✓ Fully replace natural aggregates
- ✓ Partially replace cement.

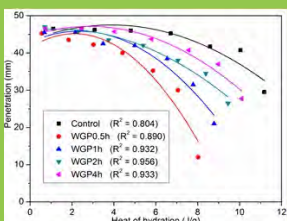

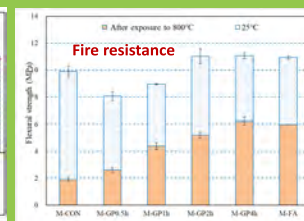
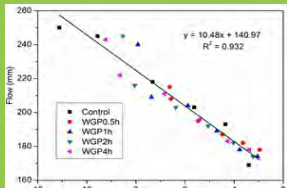
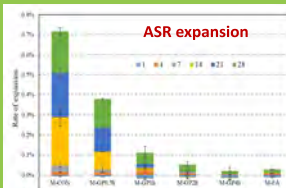
✓ **Innovative forming method:** Calender Extrusion Method can effectively improve the production process.

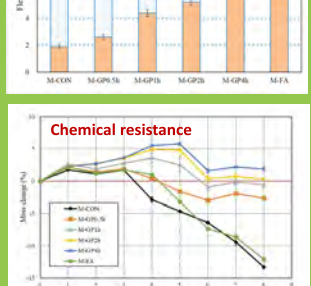






✓ **Glass-based Architectural Tile:** Attractive appearance, Cost-effective, High-quality.



Architectural Tile



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Alkali-activated Recycled Glass Construction Materials



Residential



Food & Beverage Industrial



GP OPC GGBS



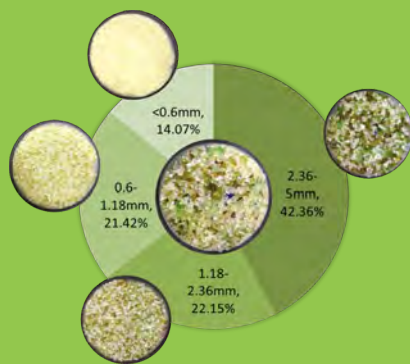
River Sand GC



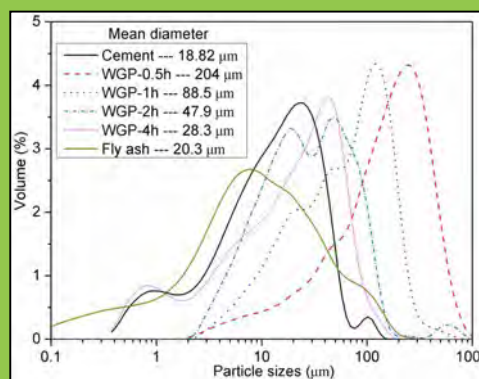
Recycling Rate of Glass Materials in Hong Kong

7% - year 2016
11% - year 2017

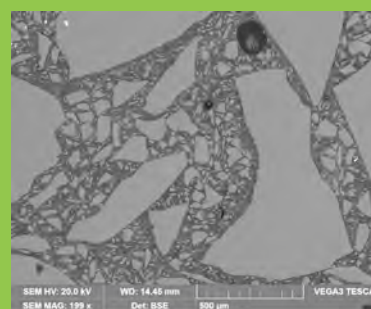
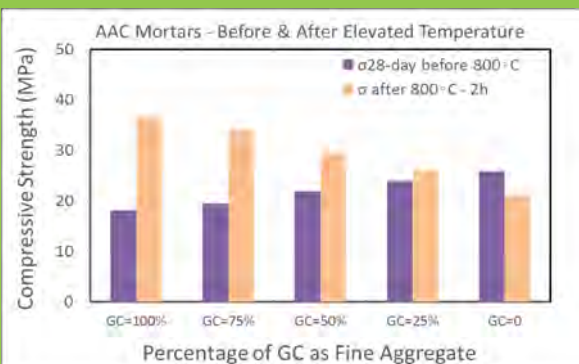
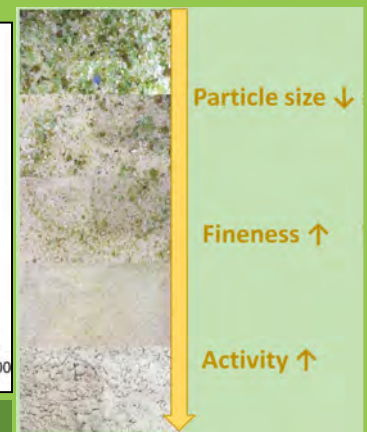
Raw Materials and Processing



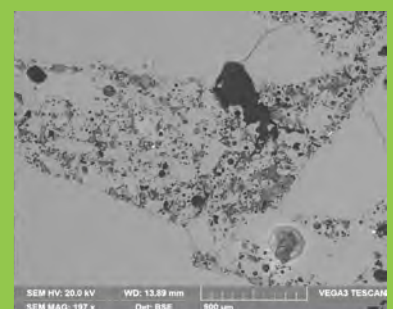
Glass Cullets Sieving



Glass Powder Grinding



Before 800°C



After 800°C

Excellent Elevated Temperature Resistance Capacity

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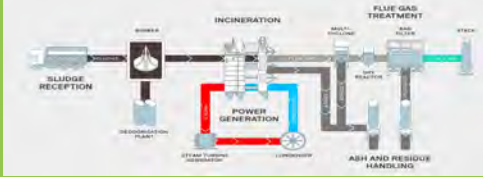
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Recycling Routes of incinerated sewage sludge ash (ISSA)

Yifan Zhou, Chi Sun Poon*


Introduction:


Due to scarcity of landfill space and public objection to its extension, Hong Kong encounters large pressure in waste management and disposal of wastes in landfills is no longer a sustainable way to management of wastes. Over **1,200 tonnes** of dewatered sludge can be produced every day in HK. For its volume reduction, HK built a huge incinerator (**T-Park**) to handle **max. 2000 tonnes** of dewatered sludge/day and sewage sludge ash is generated during this process. However, even with the reduced quantity, it is still commonly disposed at landfills in HK. Therefore, various recycling means have been urged.




Hong Kong (2019)

Sewage treatment works	11
Volume reduction	90%
GHG emissions reduction	Up to 237,000 tonnes per year
Management	Mostly landfilled





850°C



P recovery from SSA as fertilisers



Stabilisation/solidification of contaminated soils by SSA

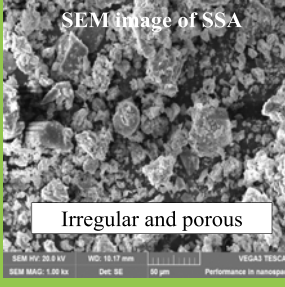


Use of SSA in construction materials

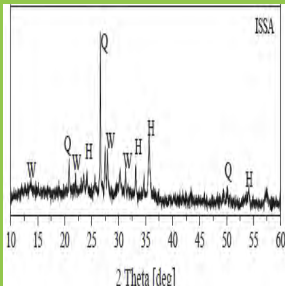
- ✓ Direct replacement for clay, sand
- ✓ Cement pastes, mortars, concretes etc.
- ✓ SCM
- ✓ Geopolymers
- ✓ Lime-SSA cements: CLSMs

- ✓ Acid (organic & inorganic) extractants were more effective than chelating agents for P recovery;
- ✓ Effective adsorbent for heavy metals removal, especially for Pb (II);
- ✓ Decreased workability & ASR expansion, increased strength & drying shrinkage, enhanced early cement hydration.

SEM image of SSA




Irregular and porous

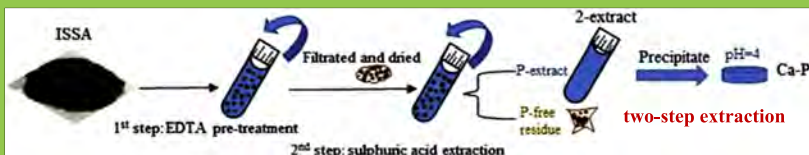


Oxide (wt%)	ISSA
SiO ₂	37.04
Al ₂ O ₃	15.24
Fe ₂ O ₃	14.03
CaO	6.91
MgO	2.8
K ₂ O	2.77
Na ₂ O	7.11
TiO ₂	0.38
SO ₃	3.66
P ₂ O ₅	9.12
Specific gravity	2.49
pH	8.45
Mean particle size	59.1 μm
Specific surface area	2.87m ² /g
LOI	0.99%


P recovery as struvite



two-step extraction




P fertiliser (cultivation of choy sum)



S/S products

P fertiliser (cultivation of ryegrass)



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Recycling of timber waste and sewage sludge ash

Timber waste in HK:

As at 2018, approximately 4,081 tones of construction waste are disposed of daily. In particular, timber boards used in formwork are the most significant waste type requiring disposal at public housing building sites in HK.

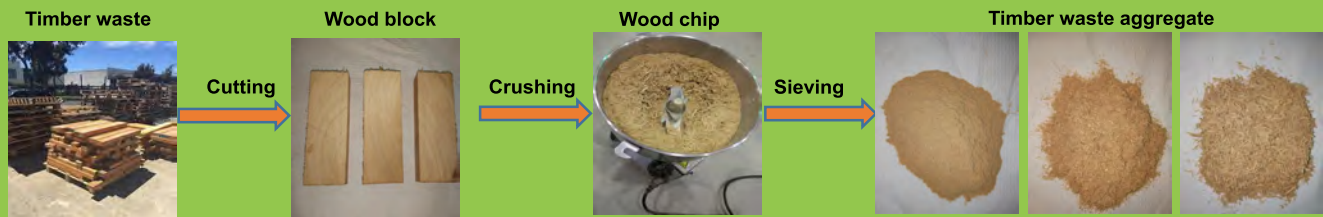
Sewage sludge ash (SSA):

Sewage sludge is a by-product of waste water treatment. The incineration process reduces the waste, leaving behind residual sewage sludge ash (SSA) and has become one of the most appropriate management options to deal with the volumes produced and the potentially unsafe elements.

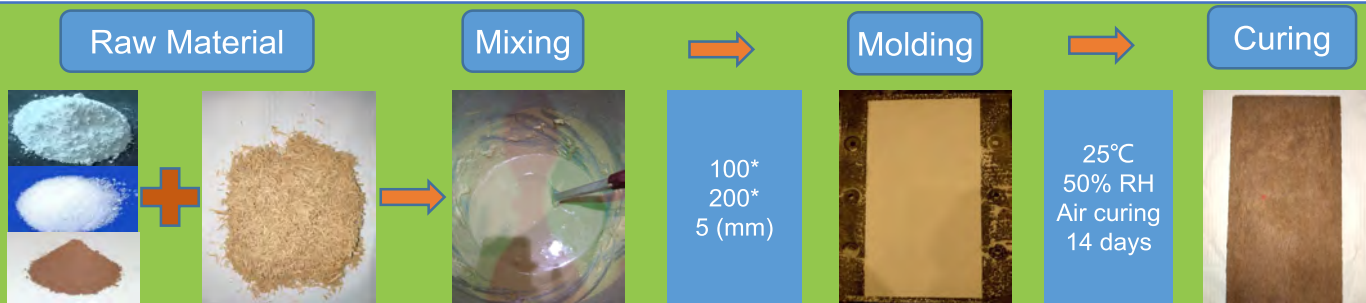


✓ **Timber waste:** using timber waste as aggregate in **magnesium oxychloride cement board** (higher compatibility; fiber function of timer waste)

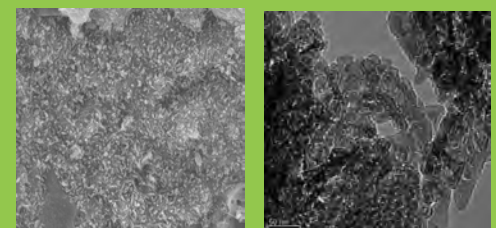
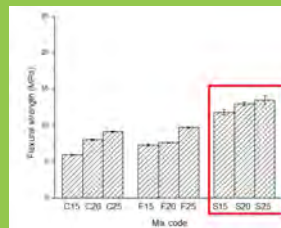
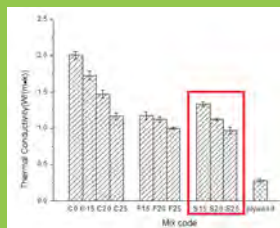
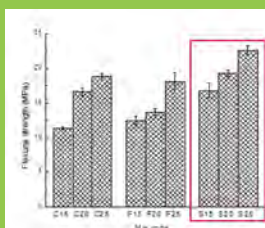
Management of timber waste aggregate



✓ **Producing magnesium oxychloride cement board using timber waste and sewage sludge ash**



✓ **Magnesium oxychloride cement board** low GHGs emission, low density, low cost, etc.



High bending strength after 28d of air curing

Low thermal conductivity after 28d of air curing

High strength after water immersion for 14d

Stable product in water

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CO₂ Curing Technique for Production of Eco-concrete Block

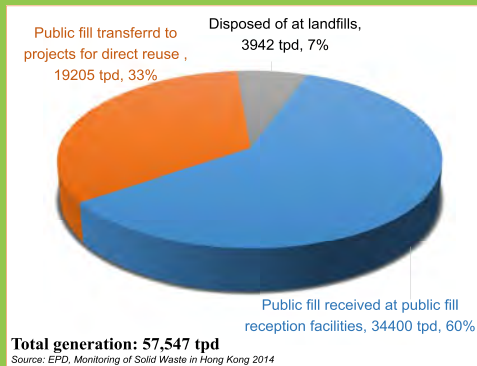
Background: Recently, Hong Kong has seen the levels of landfill waste increase consistent with its economical development and growth. Hong Kong's landfills are under significant pressure and current estimates suggest that based upon current waste generation rates, they only have capacity for the **next 5 years**. **Construction & demolition wastes** are a key consideration as they account for up to **40%** of wastes sent to landfill.



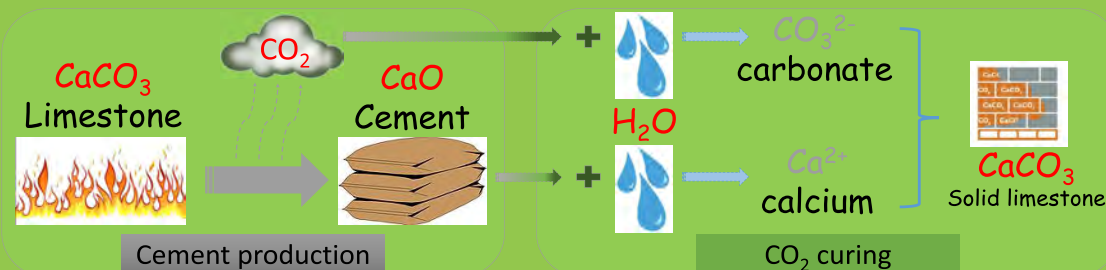
Recyclable concrete waste is estimated at **3000 -6000 tpd**.



Concrete slurry waste from concrete batching plants is estimated about **400 tpd**.



Fundamental: Recycling waste **carbon dioxide** to react with **cement** and **Construction & demolition wastes**, to make **greener concrete blocks**.



Industrial Technology Roadmapping and Environmental Benefits:



Turning construction wastes to construction products, which may be produced by up to 97% waste materials:

- CSW to replace 40-80% cement;
- RCAs to replace 100% natural aggregates.

CO₂ curing of construction products:

- Accelerated strength development (12 hours CO₂ curing ≈ 28 days air curing);
- Reduced shrinkage (50%);
- CO₂ uptake of the product is 5.2% by weight.

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