



GREEN COUNCIL
環保促進會

Webinar: Building and Construction – What are the missing hotspots?

Concrete Sustainability: from Cradle to Grave

Mr. Eddy Tsang

Chief Executive Officer

Cheung Kong Infrastructure Materials / Green Island Cement
(Holdings) Limited



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Concrete Sustainability – From Cradle to Grave

EDDY TSANG

- CEO - Cheung Kong Infrastructure (Materials Division)
- CEO - Green Island Cement/Green Island Environmental/Anderson Asphalt
- Chairman - Hong Kong Construction Materials Association

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Current
Situation

Challenges

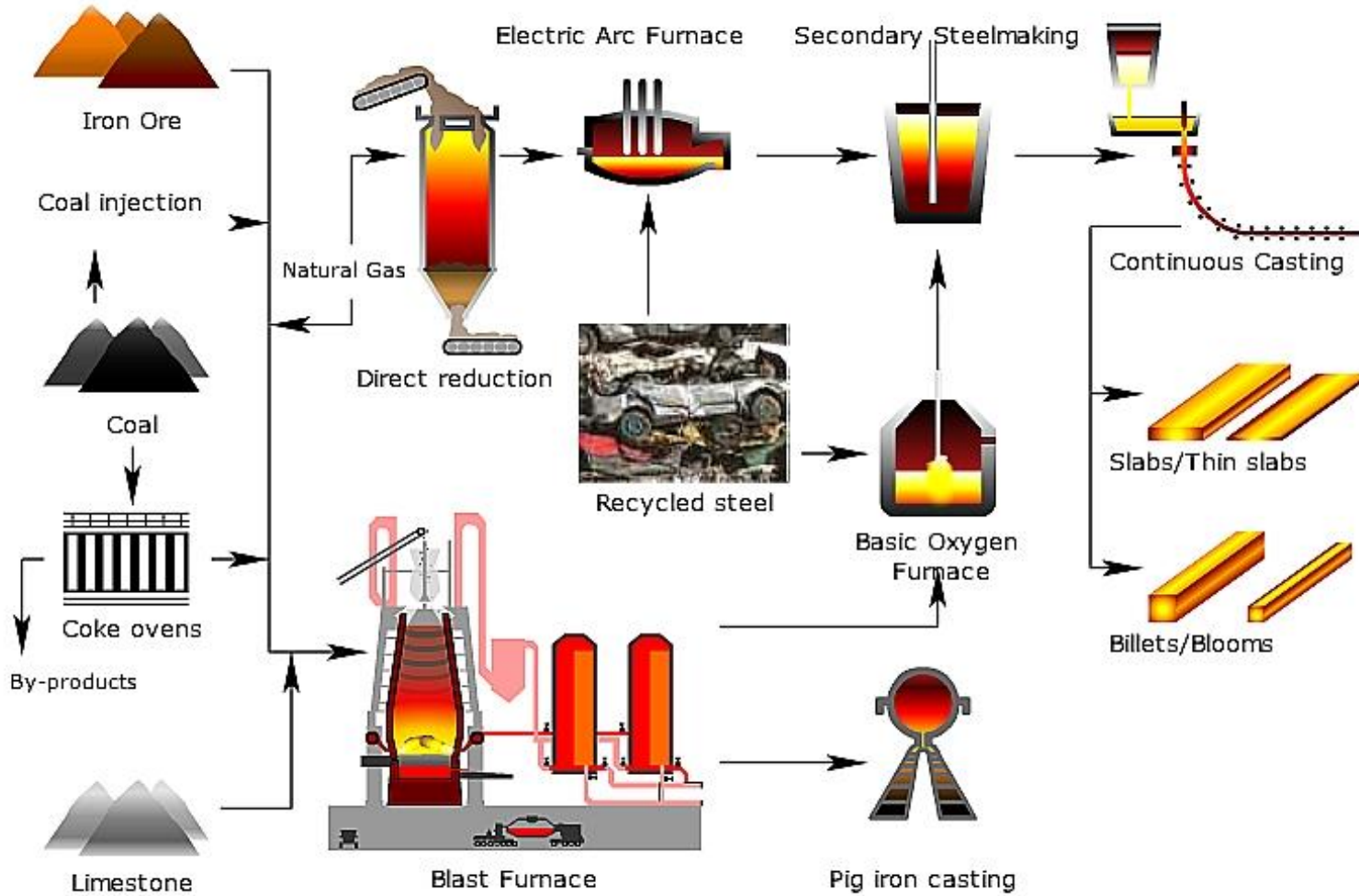
Opportunities

The Way
Forward

What are the most widely-used construction materials in the world?



Steel Manufacturing Process



Accounts for **8%** of
all global carbon emissions

(Source: Timo Gerres, Johanna Lehne, Gökce Mete, Suzanne Schenk & Caitlin Swalec (2021), *Green steel production: how G7 countries can help change the global landscape*)

What is traditional concrete?

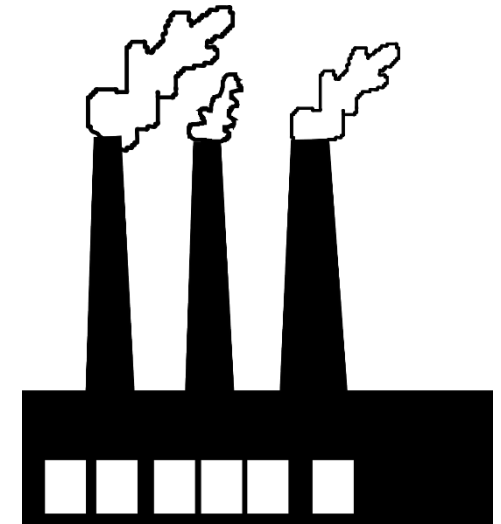


Concrete = **Cement** + Aggregates + Water + Admixtures



The major CO₂ contributing factor:
accounts for about **7%** of all global carbon emissions

(Source: International Energy Agency (2018), *Technology Roadmap - Low-Carbon Transition in the Cement Industry*)



Use of Cement ↓ → CO₂ Emissions ↓



Working Together to Build a Green Island

How to produce low carbon concrete?

Using low carbon cementitious materials to replace cement:

- Pulverized Fuel Ash (PFA)
- Ground Granulated Blast Furnace Slag (GGBS)



PFA



GGBS

Pulverized Fuel Ash (PFA)

- A by-product from coal-burning power stations
- Extracted by electrostatic precipitators
- Widely used in Hong Kong for a long period of time
- Replacement Percentage:



HKE - Lamma Power Station

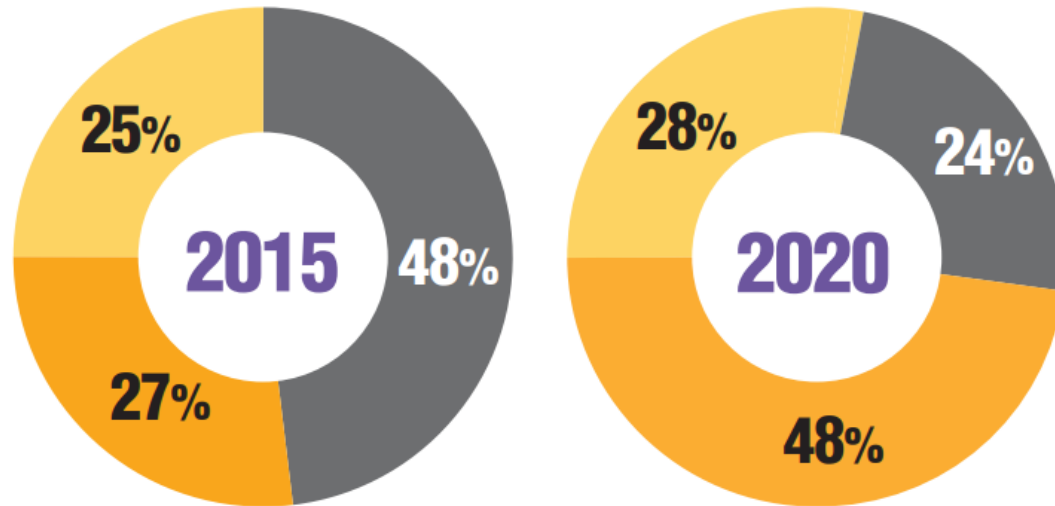


CLP - Castle Peak Power Station

Challenges of Using PFA

- Coal Combustion ↓ → PFA Supply ↓

Hong Kong's Fuel Mix for Electricity Generation



■ Nuclear and RE ■ Natural gas ■ Coal



(Source: The Government of the HKSAR (2021), *Hong Kong's Climate Action Plan 2050*)

Ground Granulated Blast Furnace Slag (GGBS)

- A by-product from blast furnace during steelmaking
- Chemical components of molten slag: $\text{CaO} + \text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{MgO}$

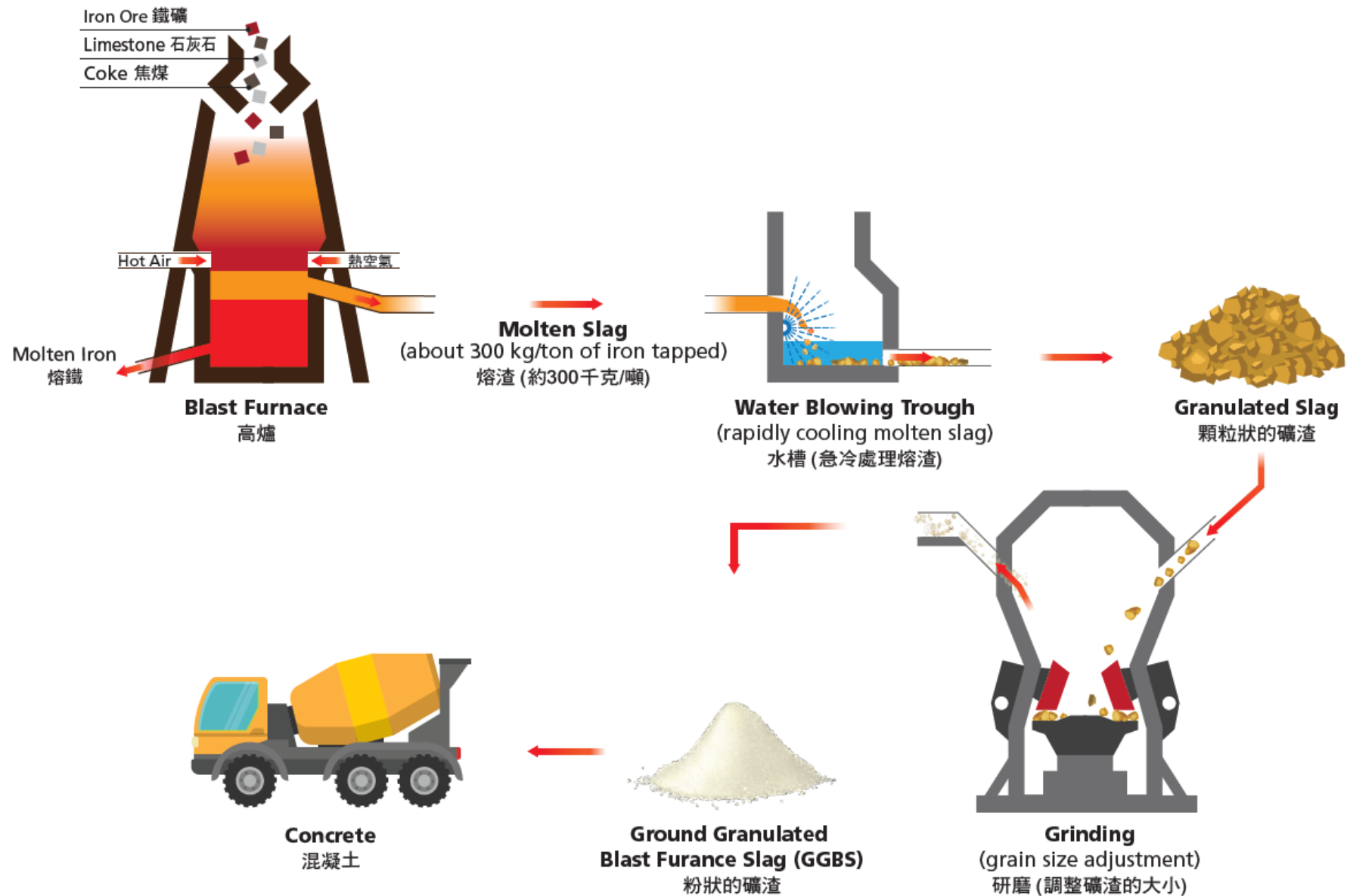


Blast Furnace



Slag Grinding Plant

Process of GGBS Concrete 礦渣混凝土流程



Benefits of Using GGBS - Durability



Produce more durable concrete



Reduce chloride ingress

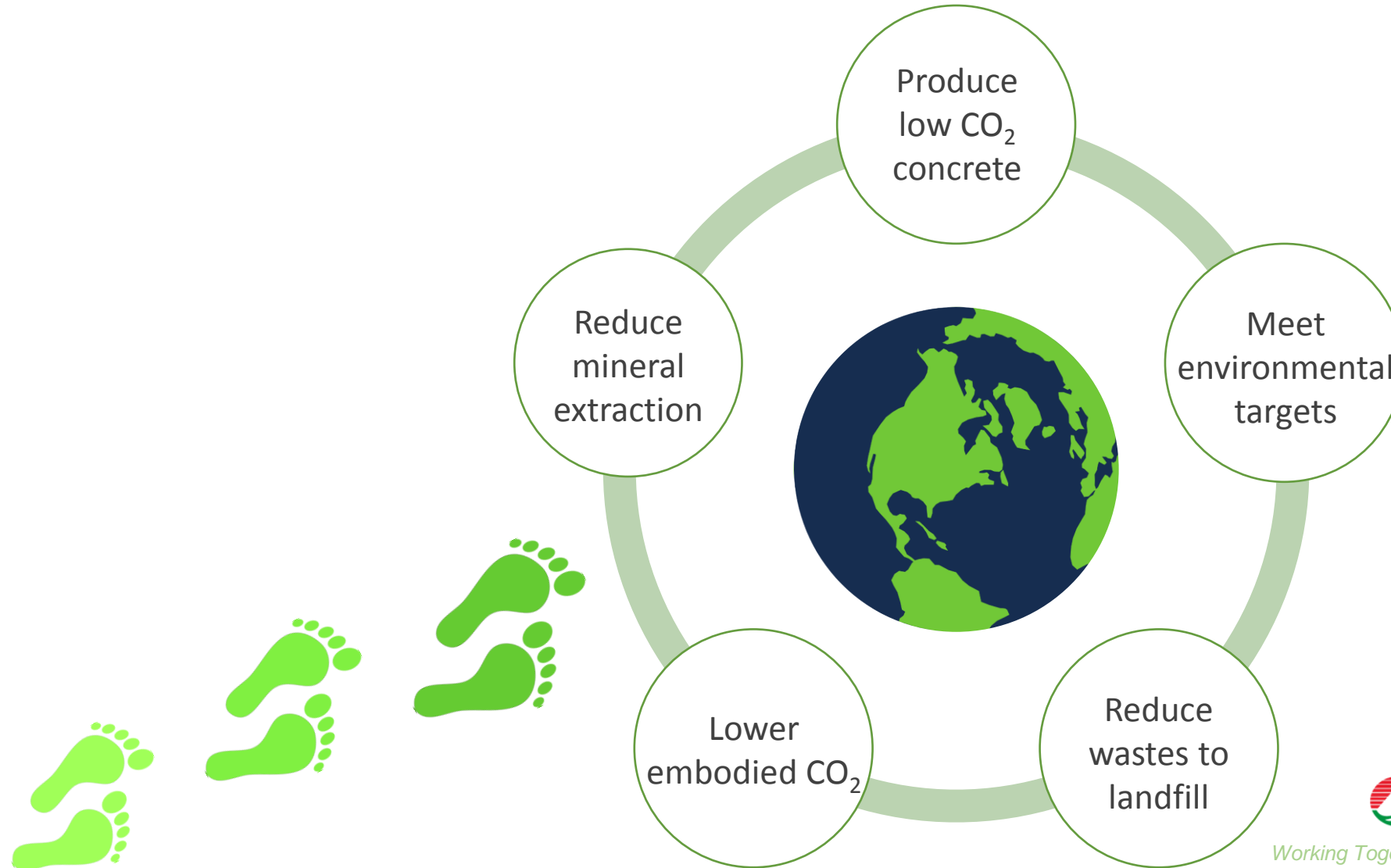


Increase sulphate resistance



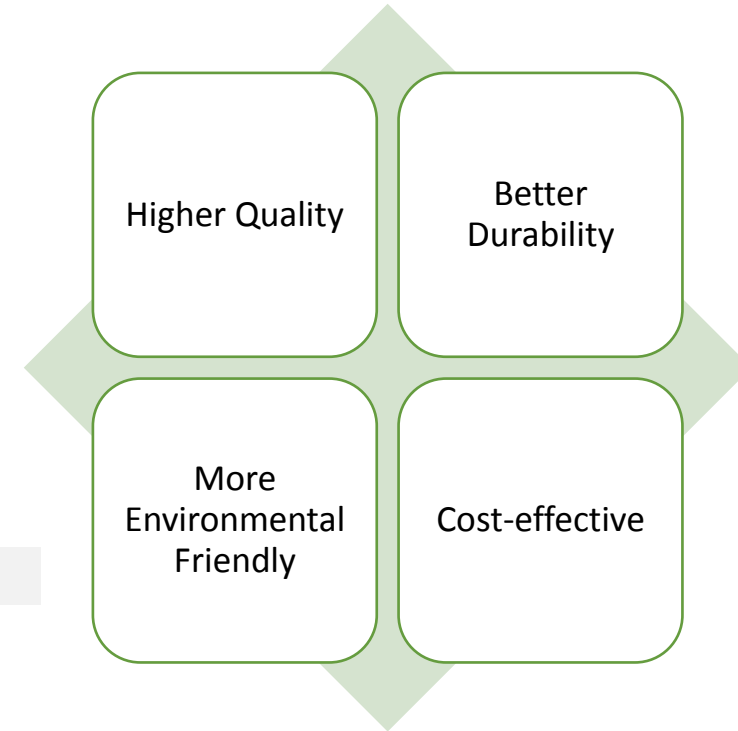
Reduce heat of hydration

Benefits of Using GGBS - Sustainability



GGBS - Application in Concrete

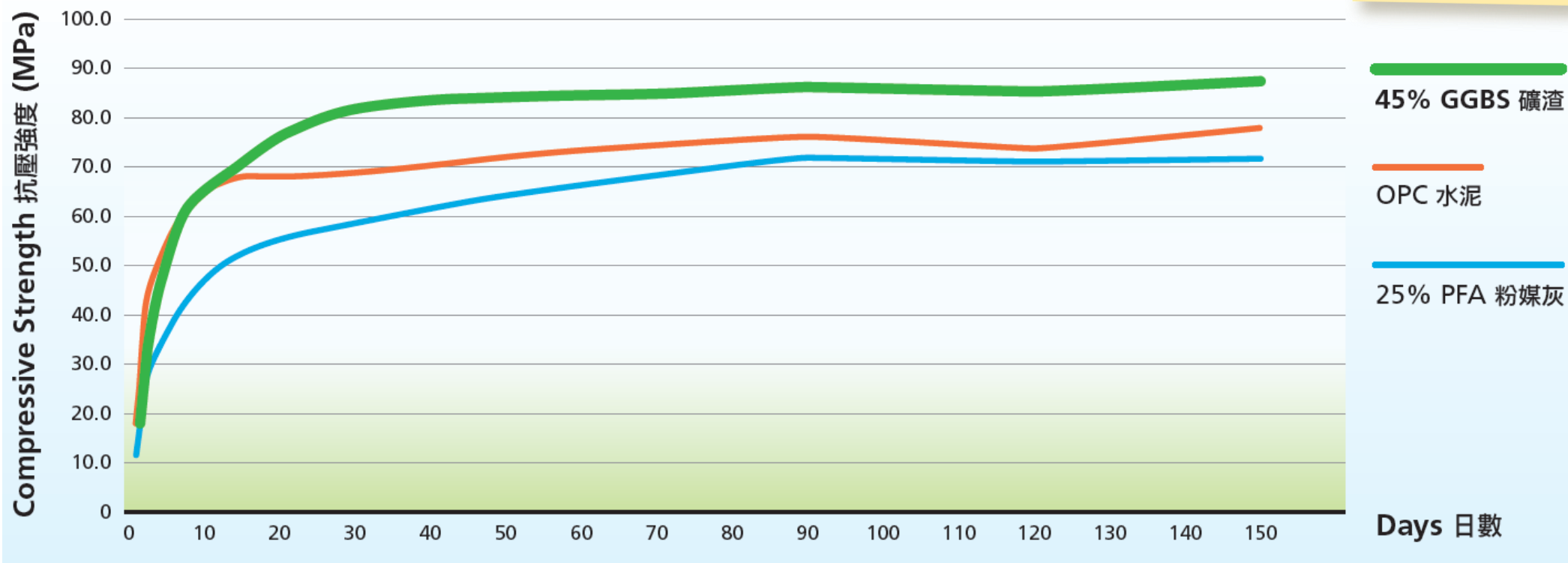
- Commonly used in Europe, United States, China and Southeast Asia
- Suitable for marine works
 - ✓ Reduce the chloride ions attack
 - ✓ Improve the corrosion resistance against sulfuric acid
- Replacement Percentage:



Ideal: **45% - 65%**

*According to the requirements of various engineering specifications, the mix design can be optimized through experimental proportions.

Concrete Strength Development Profile 混凝土強度發展概況



GGBS: lower strength at early stage but a much stronger 28-day strength

45% GGBS 礦渣

OPC 水泥

25% PFA 粉煤灰

Days 日數

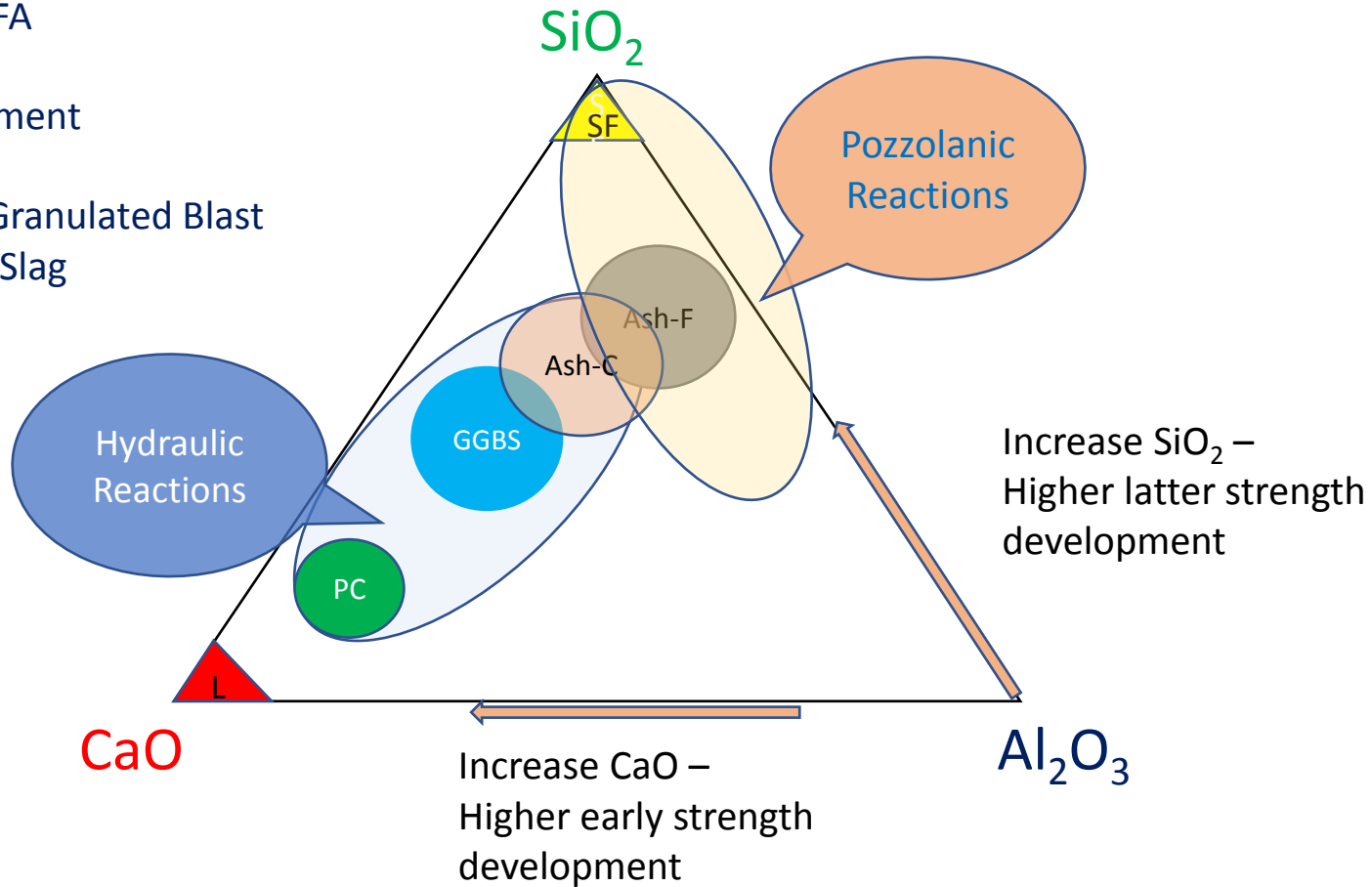
Carbon Footprint of Cementitious Materials

Total, CO ₂ kg/t Scope 1 + Scope 2	Scope 1 – Clinker Production		Scope 2 – Power Generation		Total (kg CO ₂ /t)
	Calcination of Raw Material	Fossil Fuel Combustion	Clinker Production	Finish Grinding	
OPC	468	315	41	27	850
Classified pfa*	-			13	13
GGBS*	33 (Included IDO used in drying of slag on site)			27	60

* Exclude the carbon emission in the primary process

Ternary System $\text{CaO}-\text{Al}_2\text{O}_3-\text{SiO}_2$

- Ash-F – Type F PFA
- Ash-C – Type C PFA
- L – Lime
- PC – Portland Cement
- SF – Silica Fume
- GGBS – Ground Granulated Blast Furnace Slag

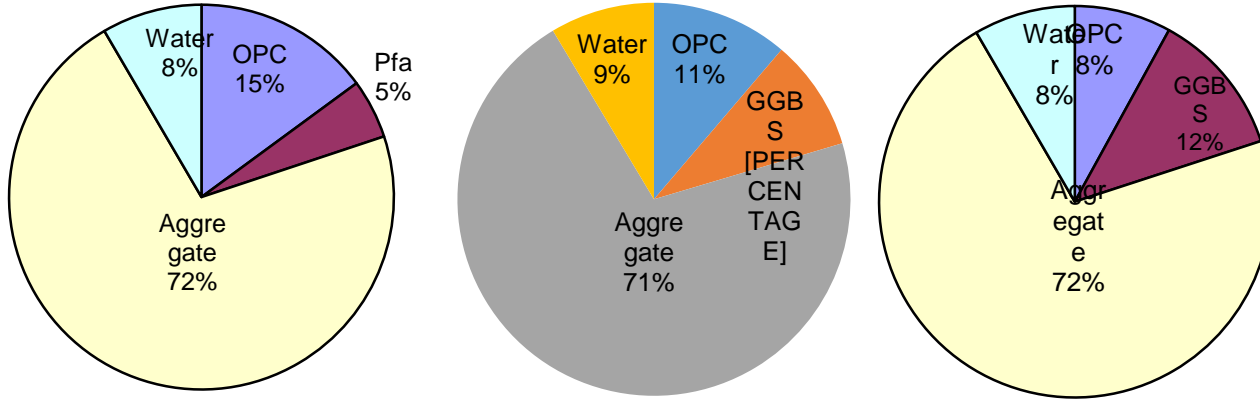


Strength of GGBS and PFA Concrete

Concrete Mix	Grade 60D/20 – 200 mm 35% GGBS	Grade 45D/20 WP – 100mm 60% GGBS
Location	Wall, beam & column	Water tanks
OPC/(GGBS)	Total 500 kg/m ³ (OPC:200/GGBS:300)	Total 470 kg/m ³ (OPC:188/GGBS:282)
7 days concrete strength, MPa	76.7 (87% of 28 days')	48.0 (67% of 28 days')
28 days concrete strength, MPa	88.2	71.2
Concrete Mix	Grade 60D/20 – 200 mm 25% pfa	Grade 45D/20 – 100mm 25% pfa
Location	Pile caps	Footings
OPC/(PFA)	Total 500 kg/m ³ (OPC:375/PFA:125)	Total 470 kg/m ³ (OPC:352/PFA:118)
7 days concrete strength, MPa	63.8 (76% of 28 days')	50.7 (68% of 28 days')
28 days concrete strength, MPa	84.5	74.7

PFA to GGBS Concrete

Typical 45/20D concrete



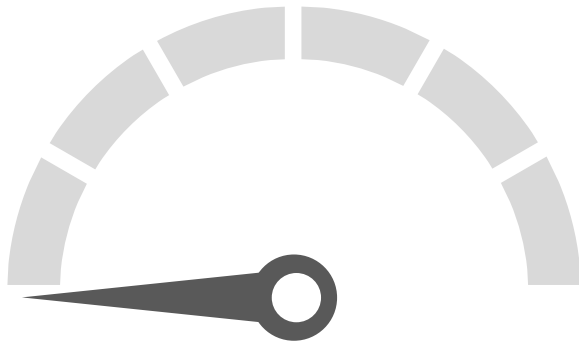
As compared to OPC mix:

	25% PFA	45% GGBS	60% GGBS
Cement reduction, kg/m ³	80 kg (19%)	169 kg (40%)	238 kg (56%)
CO ₂ reduction, kg CO ₂ /m ³	67 (19%)	131 (37%)	186 (52%)
Durability	Improve Heat Evolved	Improve Heat and Chloride Diffusion Penetration	

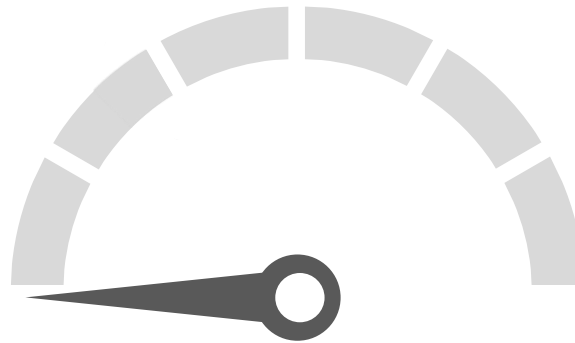
Market Prospective



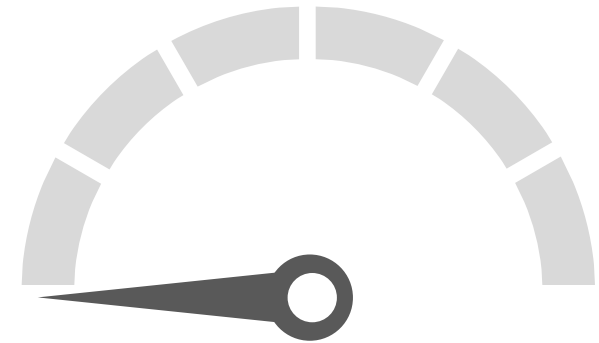
**Average Concrete Consumption in Hong Kong:
6,000,000 m³/year**



**0 PERCENT
CEMENT SUBSTITUTES**
Cement Consumption:
2,700,000 mt



**25 PERCENT
PFA**
Cement Consumption:
2,025,000 mt



**50 PERCENT
GGBS**
Cement Consumption:
1,350,000 mt



Green Island Cement
青洲英坭

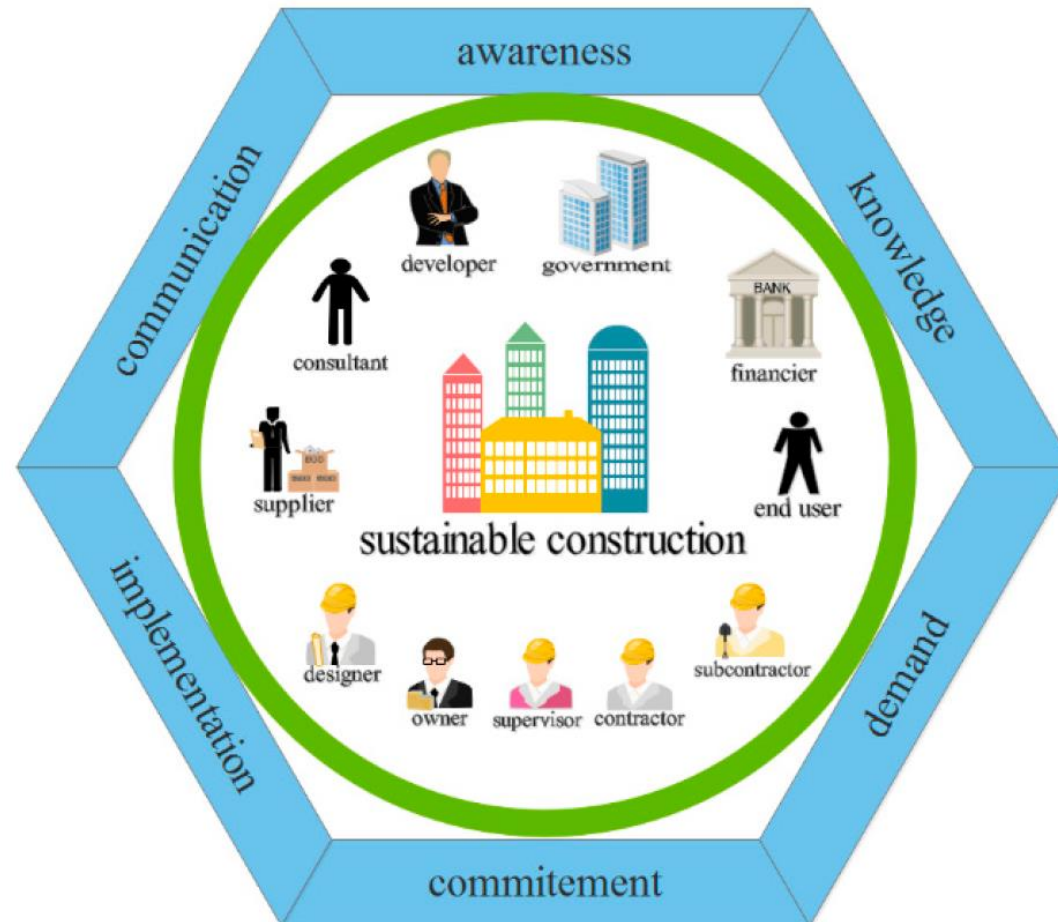
Working Together to Build a Green Island

Changes start with All of Us



Let's get started!

Stakeholders and Factors Surrounding Sustainable Construction



Let's get started - Challenges

- Before: No incentive to go GREEN
- Owners/Consultants: Too conservative
- Concerns over the setting time and early strength
- Silo limitation



Let's get started!



Work Together for Win-Win Cooperation





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Working Together to Build a Green Island



THANK YOU!

