港興 QUON HING CONCRETE CO., LTD.

Introduction of GGBS concrete

Introduction of Quon Hing

Established in 1985 and registered in Hong Kong as a subsidiary of NWS Holdings.

One of the ready-mix concrete, instant mortar and precast concrete provider to construction and infrastructure industry in Hong Kong.

Concrete

- Two concrete production plants in Tsing Yi and Tai Po
- Annual production capacity more than 750,000m3
- Concrete supplied up to C100
- All GGBS, PFA concrete mixes with Platinum Green Label

MiC

- Operates three industrial parks in GBA, annual production capacity more than 230,000T
- With 25 years of engineering experience in the Guangdong-Hong Kong-Macao
- Specializing in the production of MiC and precast concrete elements

Quon Hing's Green Products

<u>Green and Sustainable Concrete Products</u>

- Negative/Low Carbon Concrete
- Tivoli Green Wall System (Lightweight partition wall)
- H-Crete (Waterproofing Concrete System)
- Smart Drainage Cover (Material for sponge city)
- Capsule Concrete (Lightweight structural concrete)

Contents

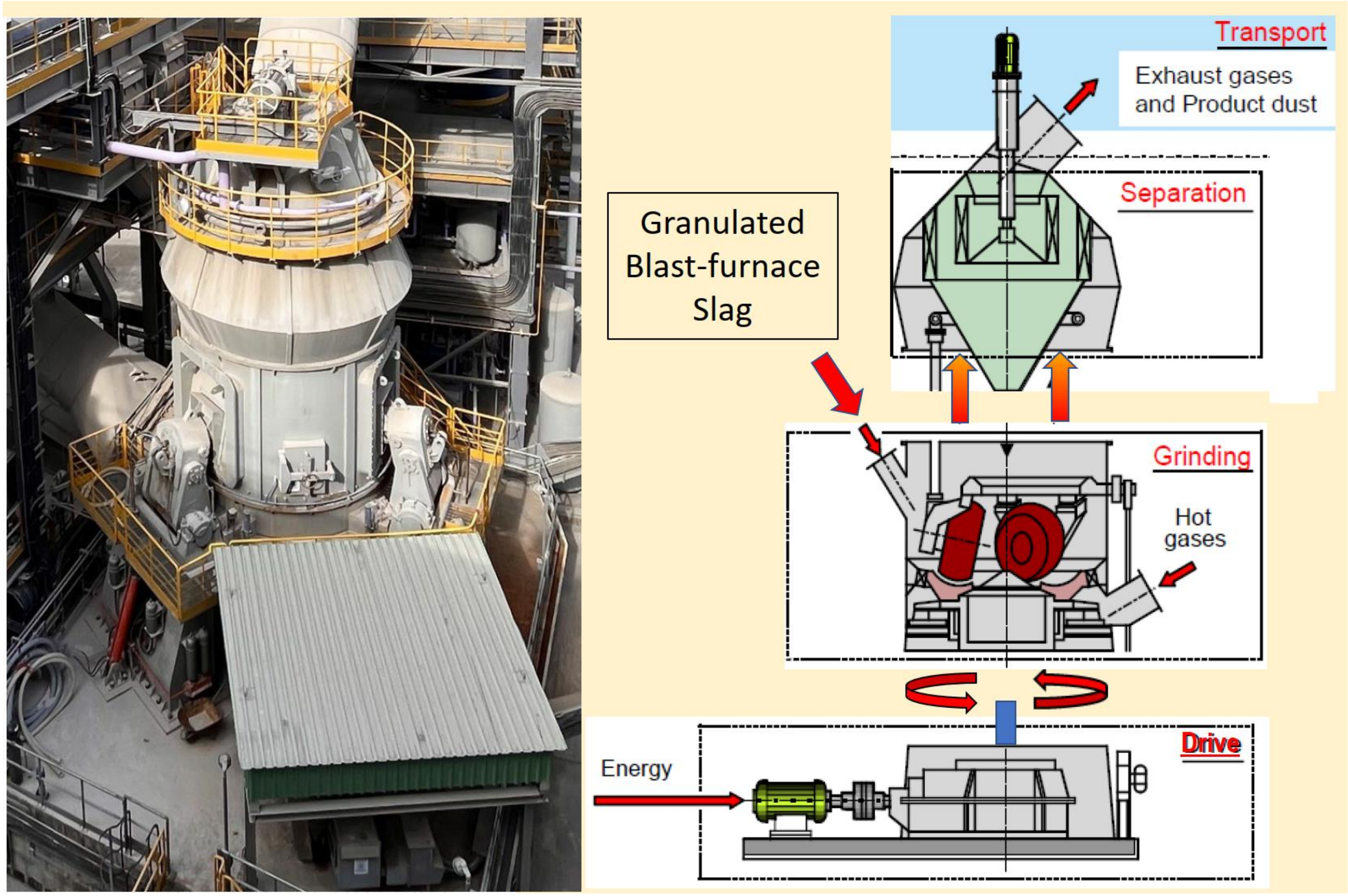
1. INTRODUCTION OF GGBS -

- WHAT IS GGBS?

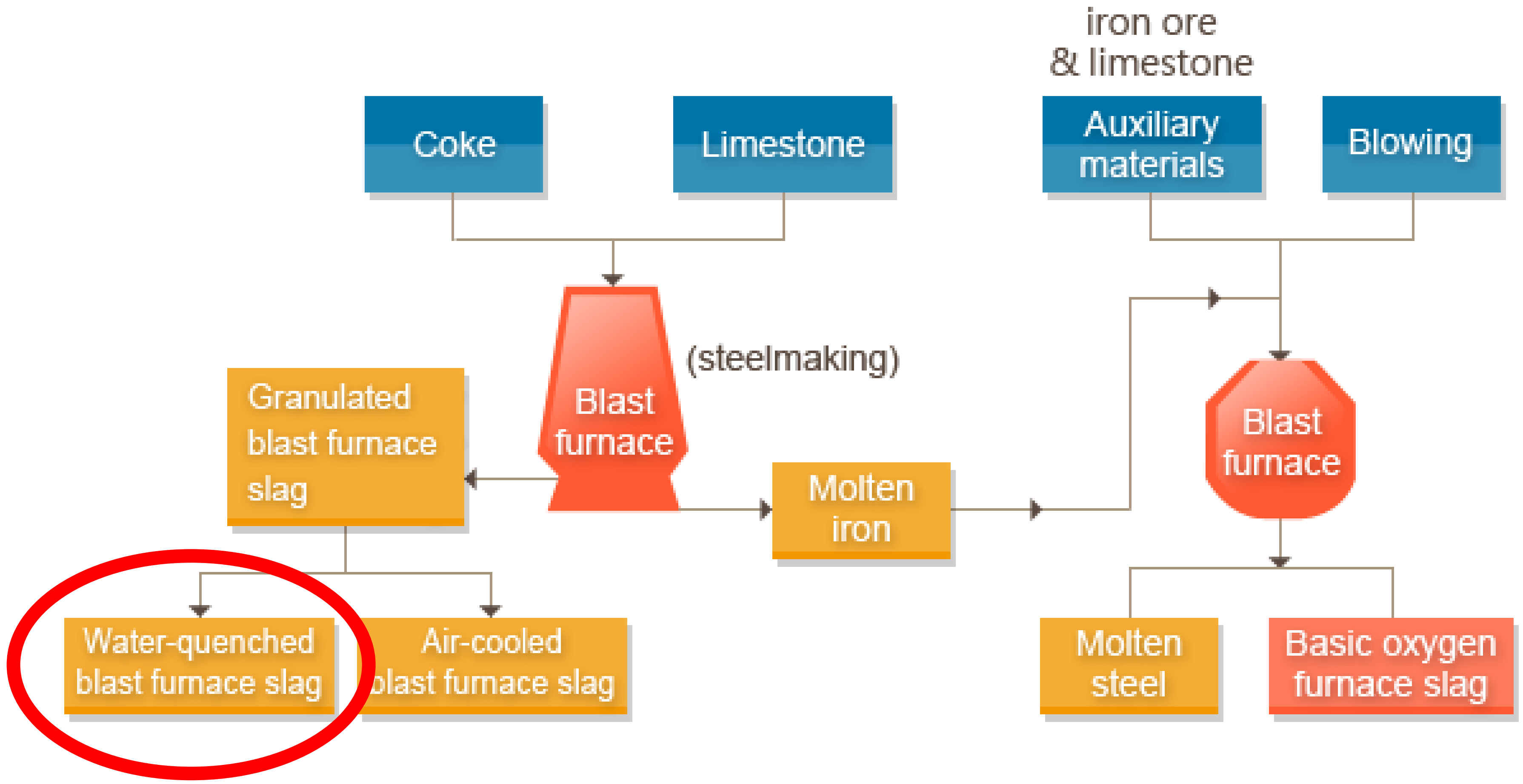
Blast Furnace Slag

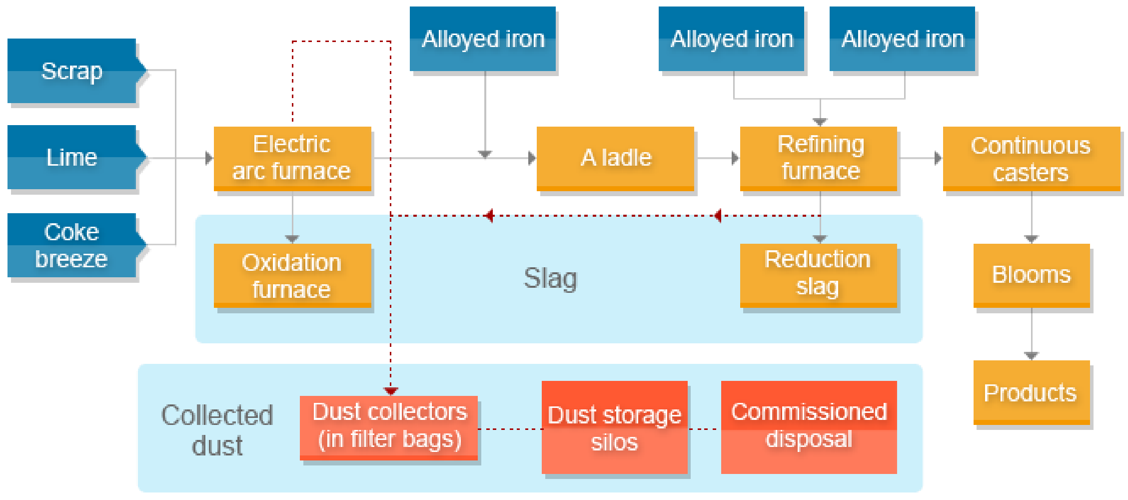
Granulated Blast Furnace Slag

Ground Granulated Blast Furnace Slag

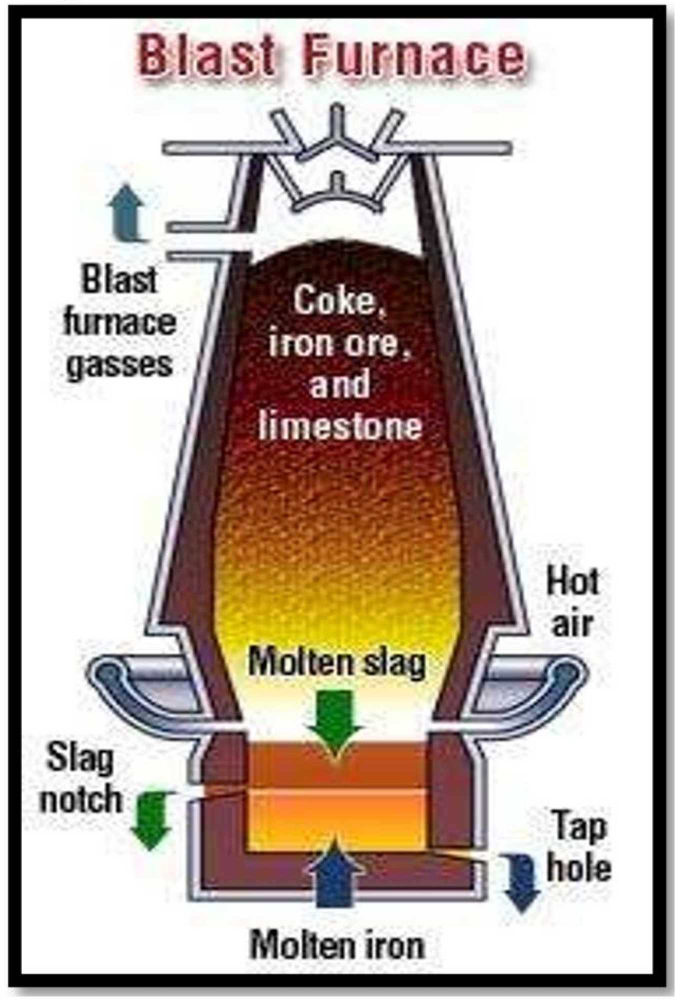


Manufacturing Process





The Production Flow Chart of Slag in an EAF Steel Mill



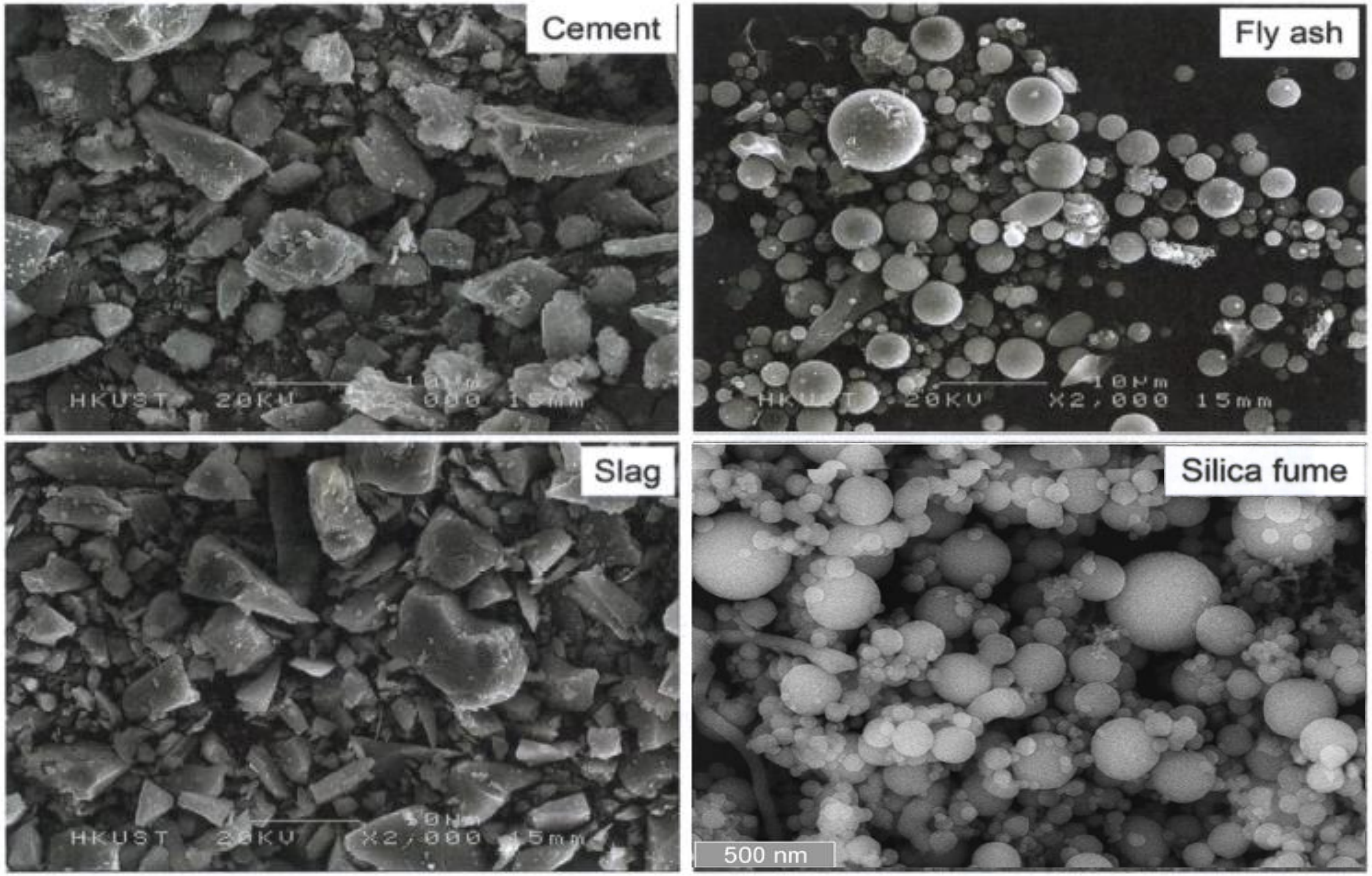
- **Blast-Furnace Slag (BFS)**
  Production process of smelting iron ore, coke, limestone, and other raw materials in a blast furnace is known as blast furnace slag.

- **Basic-Oxygen-Furnace Slag (BOFS)**
  Produced during the process of converting molten iron from a blast furnace into steel in a converter

- **Electric-Arc-Furnace Slag (EAFS)**
  Production process of melting scrap steel at high temperatures using an electric arc furnace, where scrap steel is the primary raw material, is known as electric arc furnace slag.

Binding Materials

- The following material are normally used to produce a robust paste



Chemical Composition Of SCM-GGBS

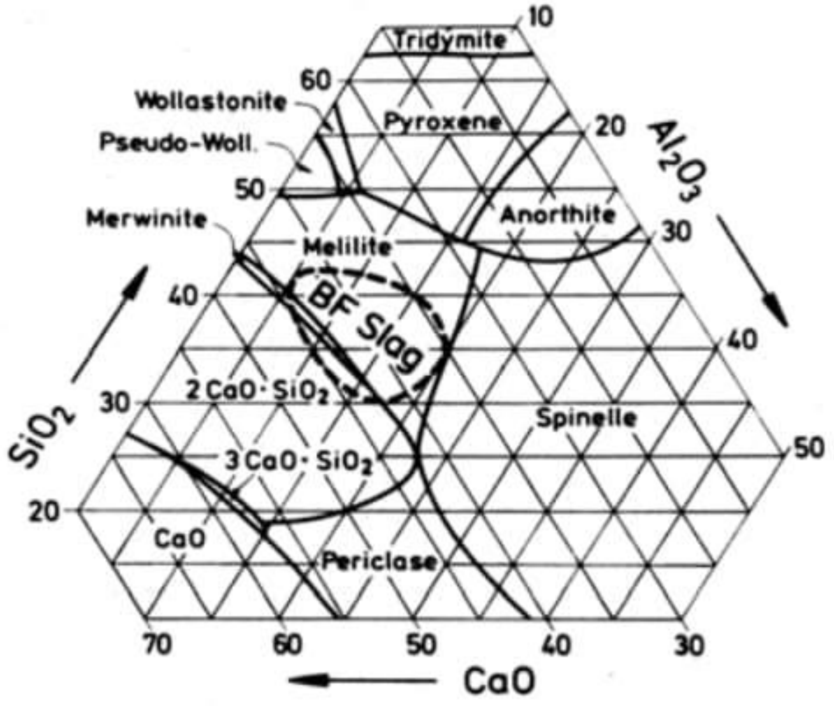
Range for Chemical Composition of Slag		
Composition	*Usual range*	*Typical range*
Silicon Dioxide (SiO_2)	30–45	36
Aluminum Oxide (Al_2O_3)	8–20	16.0
Calcium Oxide (CaO)	35–50	43.3
Magnesium Oxide (MgO)	0–20	7
Ferrous Oxide (FeO)	0–1.6	0.4
Sulfide sulfur (S)	0–2	1.5
Manganese Oxide (Mn_2O_3)	0–2.5	< 0.1

Graphical Representation of Chemical Composition of Slag

Amorphous Content > 90 % (Best 95%)

$$\frac{CaO + MgO + \frac{1}{3}Al_2O_3}{SiO_2 + \frac{2}{3}Al_2O_3} \geq 1.0$$

Total amount of SiO2+MgO+CaO>66%



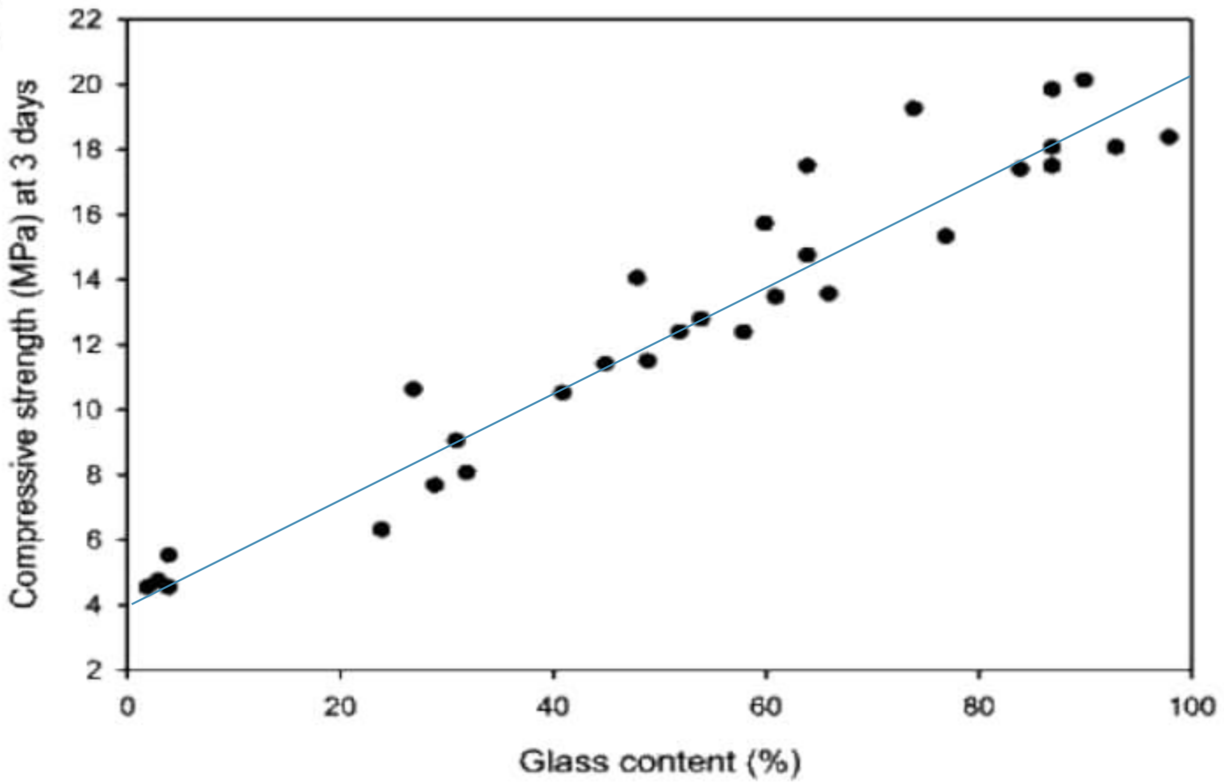
By-products: sustainability in society

As the glass phase content constitutes one of the essential features of slag, various methods have been proposed for measuring the degree of crystallinity.

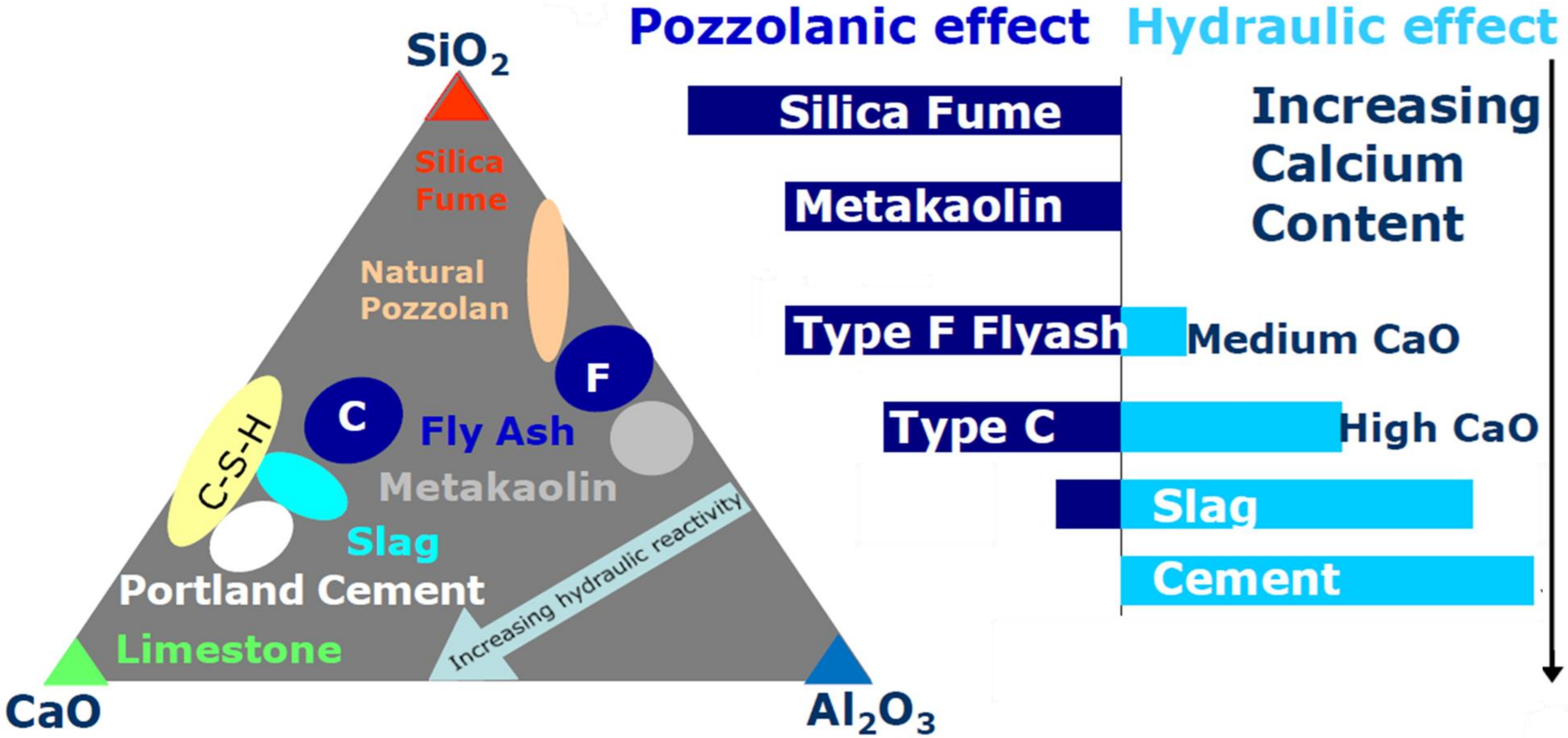
Owing to stress birefringence, it is difficult to distinguish between the crystalline phase and the stressed glassy phase.

From SEM, it is found that potassium and sulphur are localized mainly in the glass and that distribution of the elements is revealed.

With reference to crystalline phases, it has recently been shown that the richer the slag is in akermanite, the less readily it hydrates.



Binding Materials



- The pozzolanic reaction refers to the reaction of amorphous SiO2 and Al2O3 with Ca(OH)2, resulting in the formation of C–S–H and C-A-H gel

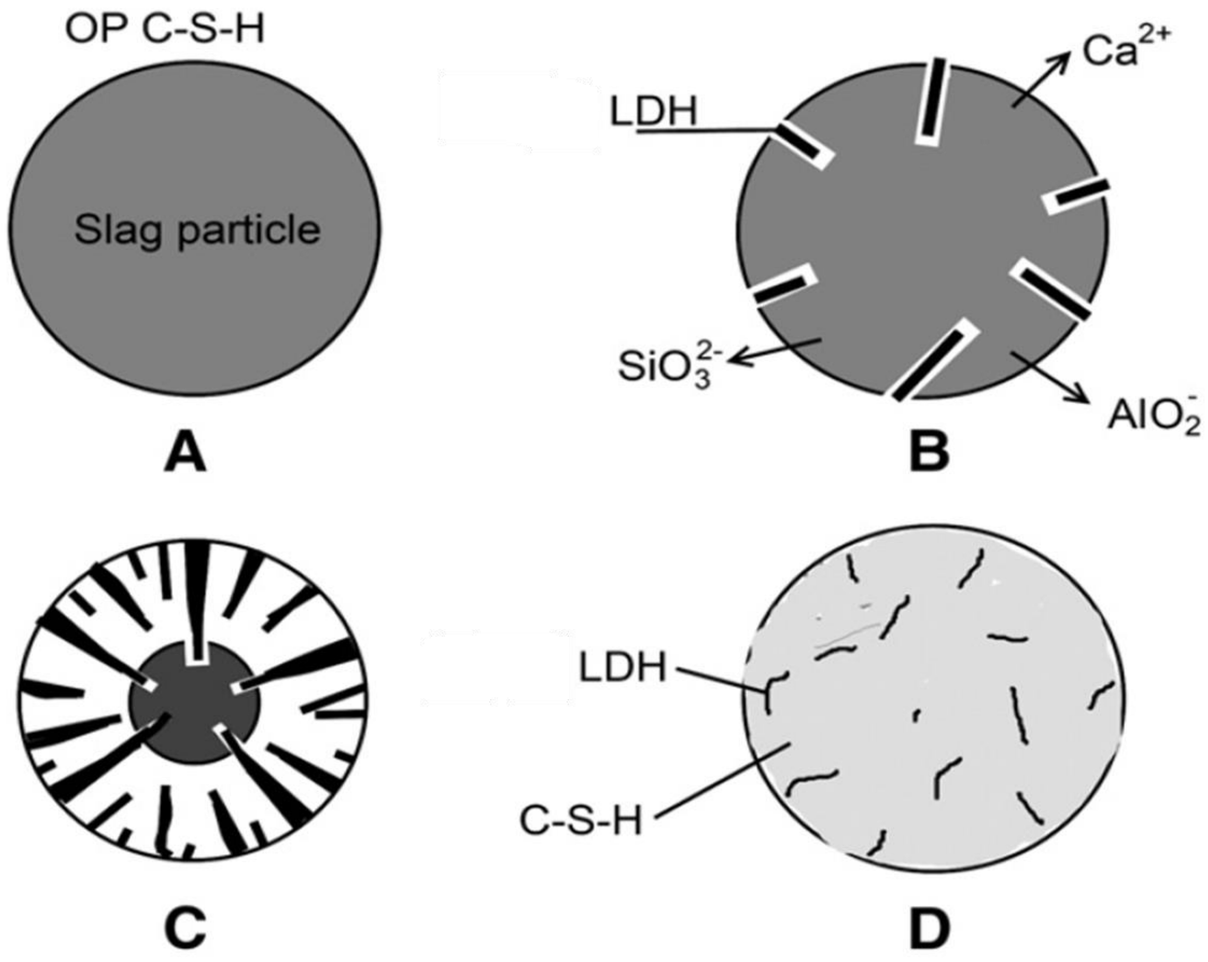
$$3Ca(OH)_2 + 2SiO_2 \rightarrow 3CaO \cdot 2SiO_2 \cdot 3H_2O$$

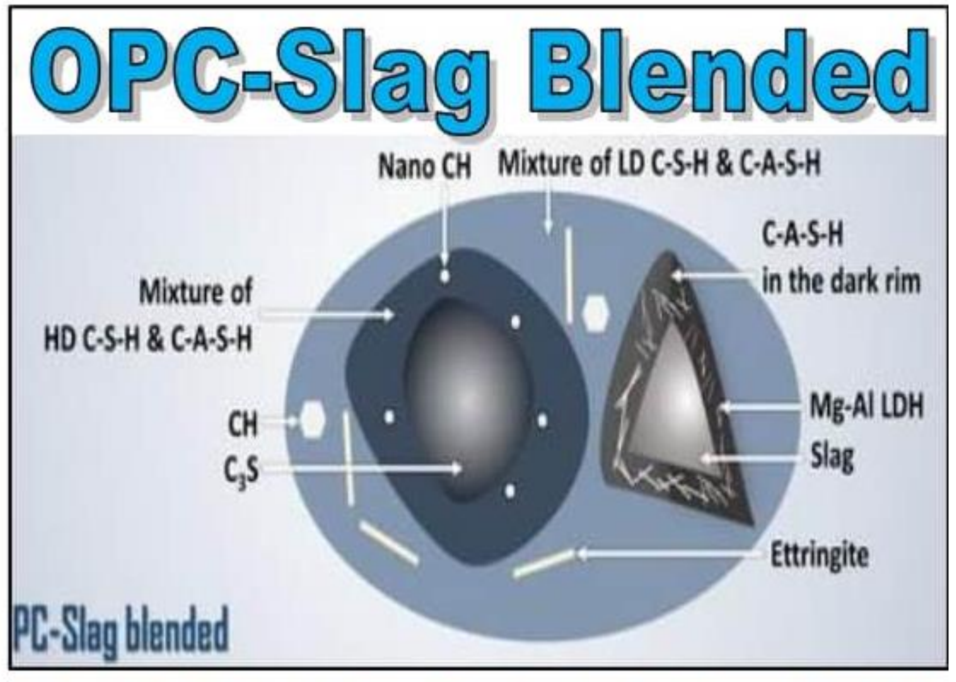
CH C – S – H

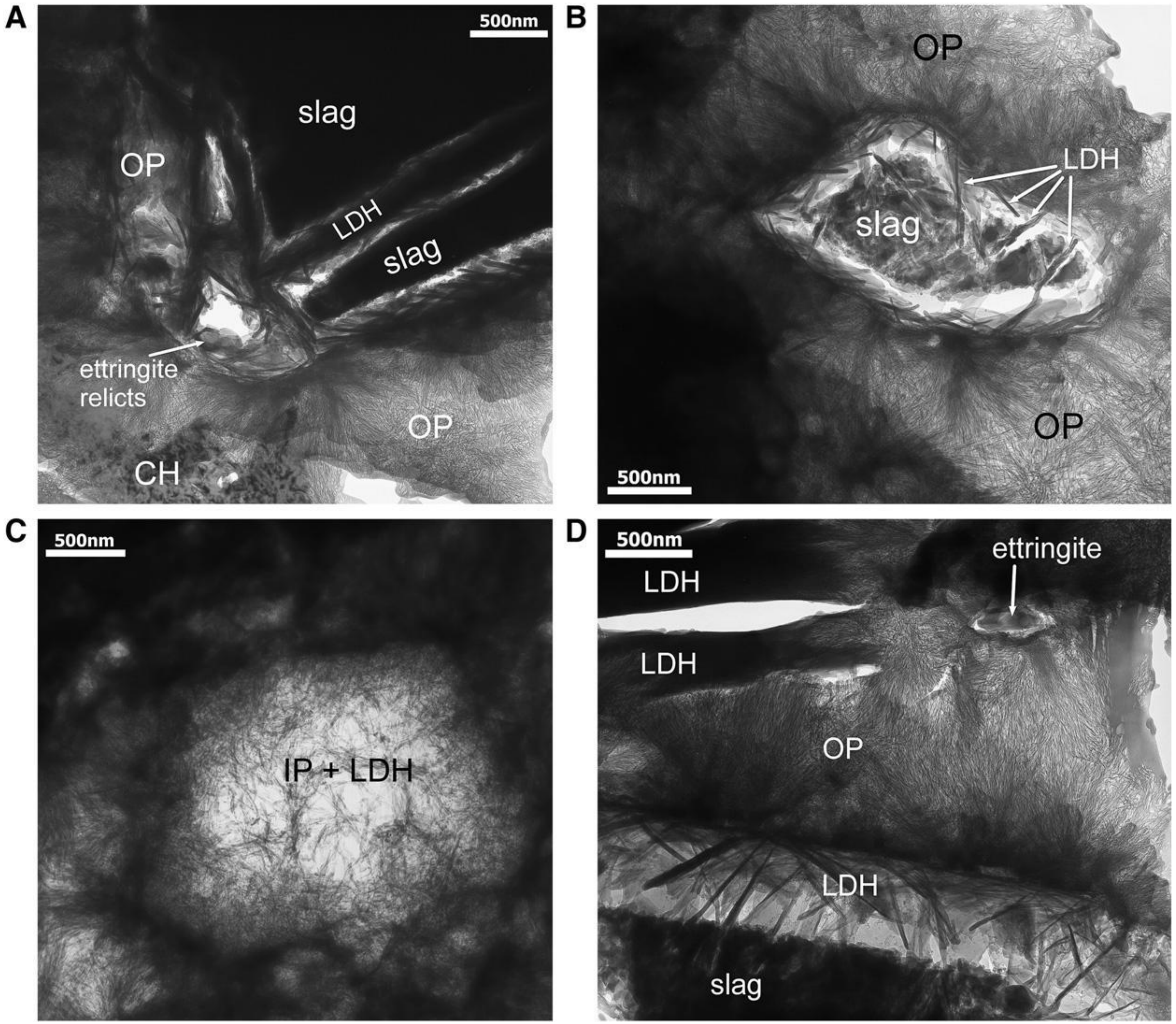
$$3Ca(OH)_2 + Al_2O_3 + 3H_2O \rightarrow 3CaO \cdot Al_2O_3 \cdot 6H_2O$$

CH C – A – H

Hydration Products of GGBS with OPC







Oversea Applications of GGBS – Concrete

- Discovered in Germany, 1862 and first commercially produced in 1865.
- GGBS was used in Europe and North America for over 100 years.
- Currently, GGBS has been widely used, particularly in China, Japan, Europe and USA.

Experience of Using GGBS in Concrete

Region	GGBS Usage
Western Europe	• GGBS accounts for about **20%** of total cement consumed
Netherlands	• GGBS accounts for **60%** of total cement consumption
USA	• Concrete in World Trade Centre construction has about **40%** GGBS replacement
	• Georgia Aquarium used **20% to 70%** GGBS replacement
	• Metro Airport Terminal Expansion used concrete with **30%** GGBS replacement
China	• GGBS widely used in major projects like Three Gorges Dam, Beijing-Shanghai Express Rail, and Hangzhou Bay Bridge
Singapore	• Launch national standard in 2008
Hong Kong	• Tsing Ma Bridge construction with GGBS replacement levels between **59% and 65%** • Stonecutter Island Bridge construction with GGBS replacement between **60% and 70%**

Specification Standard in Hong Kong

BS EN 15167-1:2006

Property		Requirements for GGBS
Physical Properties		
Moisture Content		<1.0%
Density		-
Fineness		≥275m2/kg
Initial Setting Time		S1 ≤ 2 x S2
Activity Index	7-day age	≥45%
	28-day age	≥70%
Chemical Properties		
Magnesium Oxide (MgO)		≤18%
Sulfide (S2-)		≤2.0%
Sulfate (SO3)		≤2.5%
Loss on ignition, corrected for oxidation of sulfide		≤3.0%
Chloride (Cl-)		≤0.10%

Specification Standard in GBT

GB/T 18046-2017

Property		Requirements for GGBS		
		S105	S95	S75
Physical Properties				
Density		≥2.8g/cm3		
Fineness – Blaine		<500m2/kg	<400m2/kg	<300m2/kg
Active Index	7days	≥95	≥70	≥55
	28days	≥105	≥95	≥75
Fluidity Ratio		≥95		
Water Ratio		≤1.0		
Chemical Properties				
Sulphur Trioxide		≤4.0%		
Chloride Ion		≤0.06%		
Loss on Ignition		≤1.0%		
Insoluble Content		≤3.0%		

EN 15167-1:2006
≥275m2/kg
≥45%
≥70%

2. APPLICATION OF GGBS IN CONCRETE –

- PROS & CONS AND SOLUTIONS

Advantages in performance

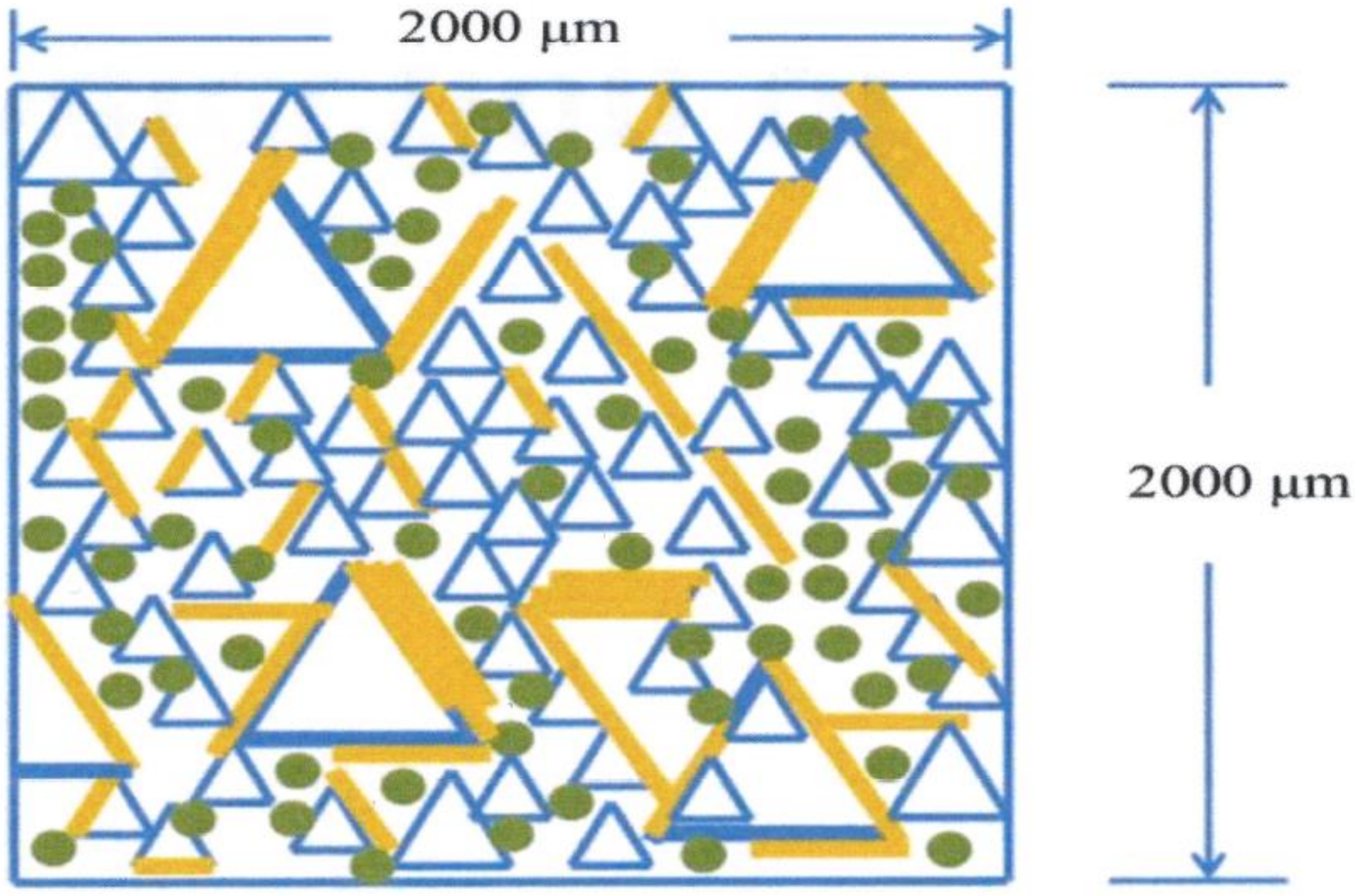
- Reducing water permeability
- Increasing corrosion resistance
- Lower peak temperature
- Better AAR Resistance

Disadvantages in performance

- Prolonged setting time
- Drying Shrinkage
- Lower early strength at initial hardening stage

Pros & Cons of GGBS Concrete

Reducing Water Permeability



- The permeability of concrete is an important characteristic of durable concrete, and concrete with a reduced water penetration depth shows significant resistance to chemical assaults

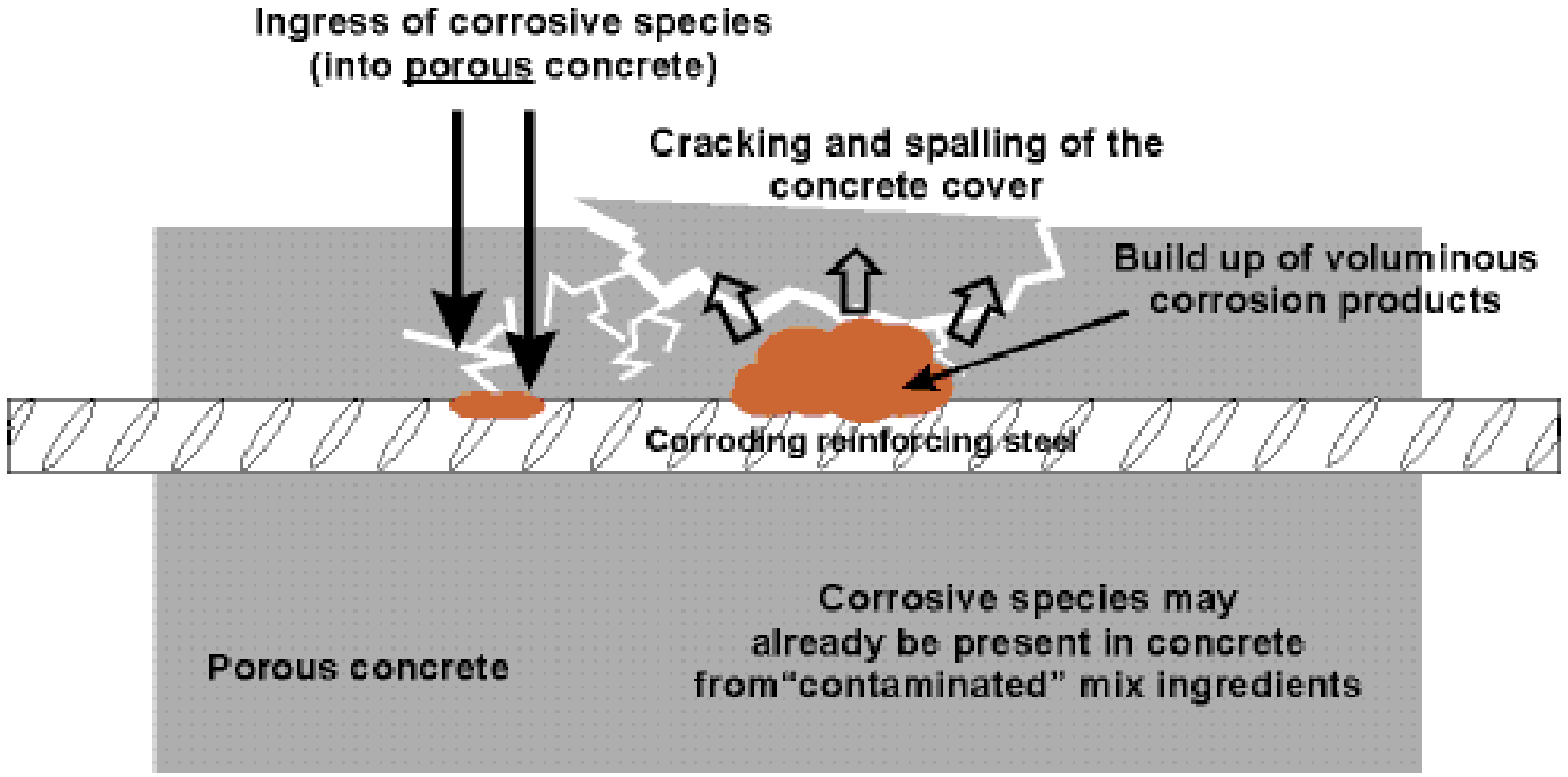
- Less voids tend to cause a decrease in the permeability of concrete.

- Concrete with a lower permeability is more resistant to chemical attack, including chloride, sulphate, AAR and acid.

Resistance of Chemical Attack

- Chloride attack is a major threat to concrete durability, causing around 40% of concrete building failures.

- The reaction of GGBS with calcium hydroxide and alkalis during hydration fills the pores with calcium silicate hydrates, improving durability against chloride penetration.



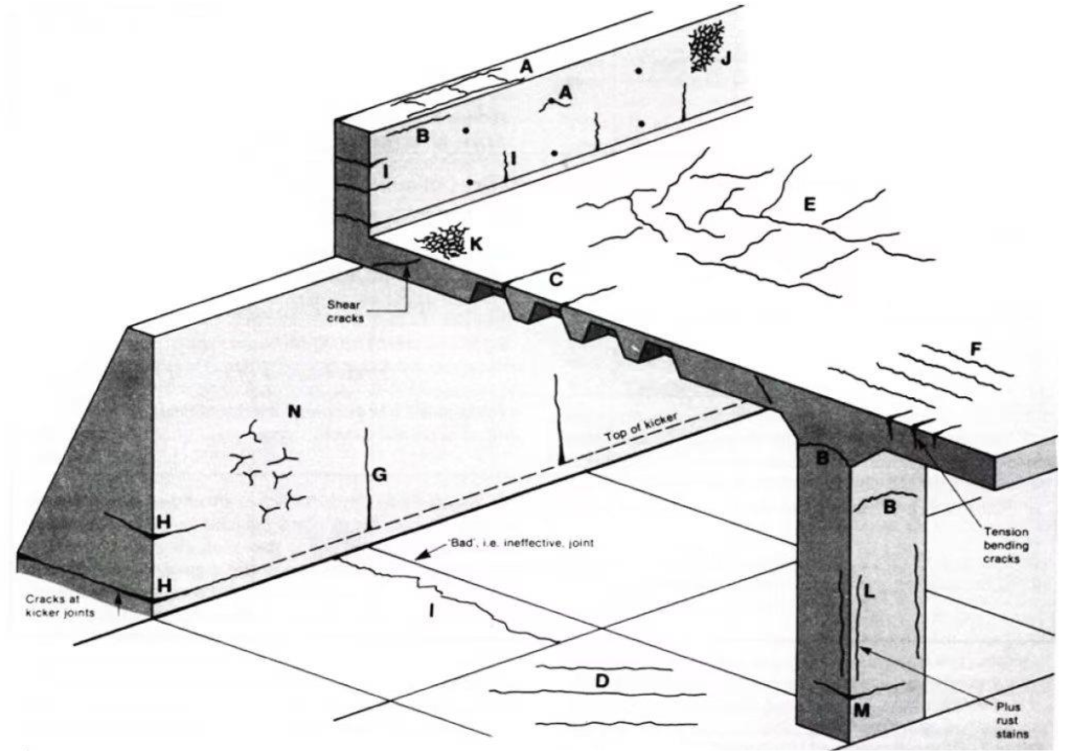
Resistance of Chemical Attack

GGBS Concrete Plant Trial with RCPT Test on 14 July 2022									
Mix		Design	Compressive Strength (MPa)						
			1 Days	2 Days	4 Days	7 Days	14 Days	28 Days	
Code	Mix	Slump	Cube	Cube	Cube	Cube	Cube	Cube	RCPT Test (Coulombs)
C45 60% GGBS+ CSF	45/20D (0.36wc)	600 Flow	14.6	27.5	40	54.5	67.3	79	89
C60 65% GGBS	60/20D (0.35wc)	200	15	29	42.5	57.5	73	80	617
C45 65% GGBS	45/20D Tremie (0.39wc)	200	-	15	28	45.5	64.35	78.5	890

- RCPT test result for OPC concrete(C45) at 28 days is about 2500 Coulombs
- Adding GGBS can lower the result to less than 900 Coulombs

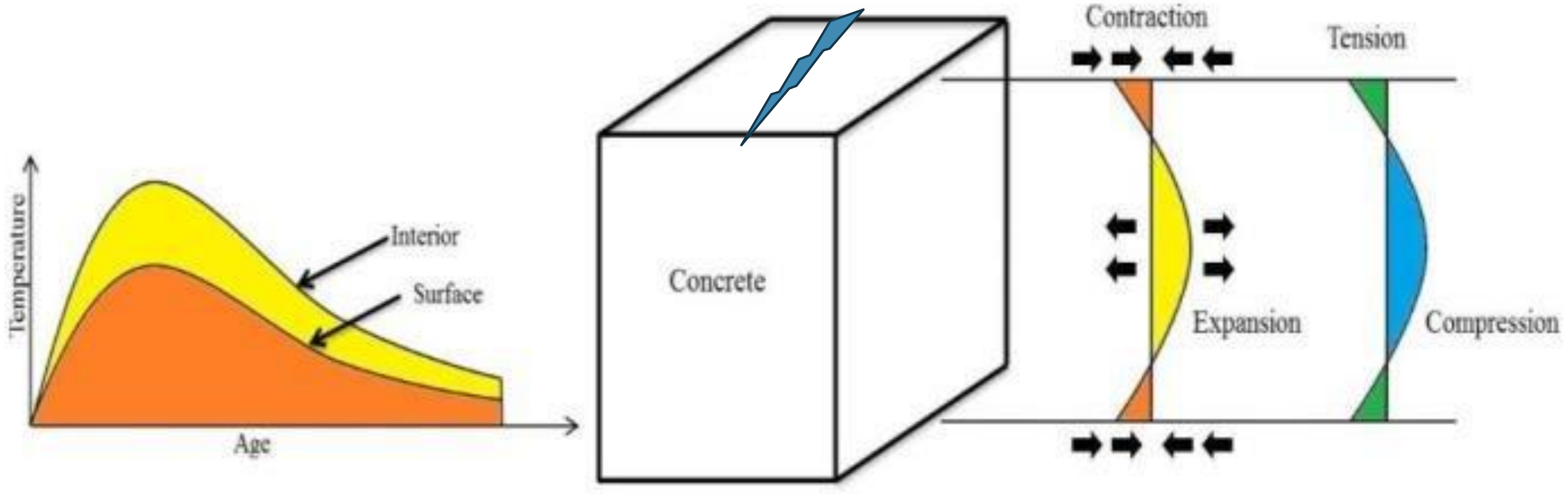
Lower Peak Temperature

- Primary causes of thermal cracking in concrete due to **temperature differentials**. Variations in temperature across the concrete structure can result in thermal gradients. When different parts of the concrete expand or contract at different rates due to temperature changes, internal stresses can build up, leading to cracking.

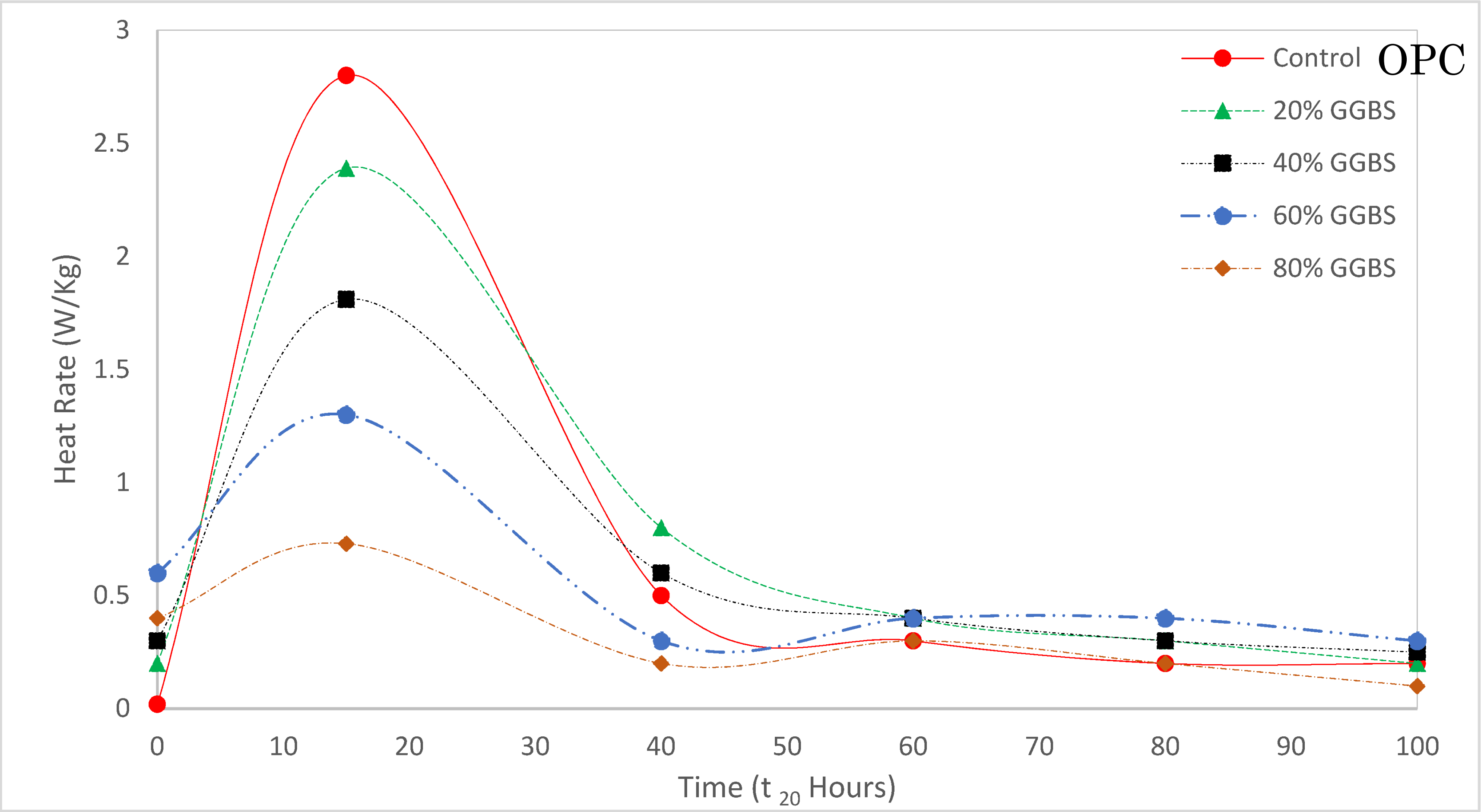


Letter	Type of Cracking	Subdivision	Most Common Location	Primary Cause (excluding restraint)	Secondary Causes/Factors	Time of Appearance
A	Plastic settlement	Over reinforcement	Deep sections	Excess bleeding	Rapid early drying conditions	Ten minutes to three hours
B		Arching	Top of columns			
C		Change of depth	Trough and waffle slab			
D	Plastic shrinkage	Diagonal	Roads and slabs	Rapid early drying	Low rate of bleeding	Thirty minutes to six hours
E		Random	Reinforced concrete slabs			
F		Over reinforcement	Reinforced concrete slabs	Ditto plus steel near surface		
G	Early thermal contraction	External restraint	Thick walls	Excess heat generation	Rapid cooling	One day or two or three weeks
H		Internal restraint	Thick slabs	Excess temperature gradients		
I	Long-term drying shrinkage		Thin slabs (and walls)	Inefficient joints	Excessive shrinkage inefficient curing	Several weeks or months
J	Crazing	Against formwork	"Fair faced" concrete	Impermeable formwork	Rich mixes	One to seven days, sometimes much later
K		Floated concrete	Slabs	Over troweling	Poor curing	
L	Corrosion of reinforcement	Natural	Columns and beams	Lack of cover	Poor quality concrete	More than two years
M		Calcium chloride	Precast concrete	Excess calcium chloride		
I	Alkali-aggregate reaction		Damp locations	Reactive aggregate plus high-alkali cement		More than five years

Example of thermal cracking



Lower Peak Temperature



- The pozzolanic reaction continues gradually and is associated with the hydration of cement, which ultimately causes a decline in the heat, especially in the early days of hydration. Resulting lower peak temperature in GGBS concrete.

Reactions of Principal Clinker Phases

$$C_3S + H_2O \rightarrow C\text{-}S\text{-}H^* + Ca(OH)_2$$

$$C_2S + H_2O \rightarrow C\text{-}S\text{-}H^* + Ca(OH)_2$$

$$2C_3A + 18H_2O \rightarrow C_2AH_8 + C_4AH_{10}$$

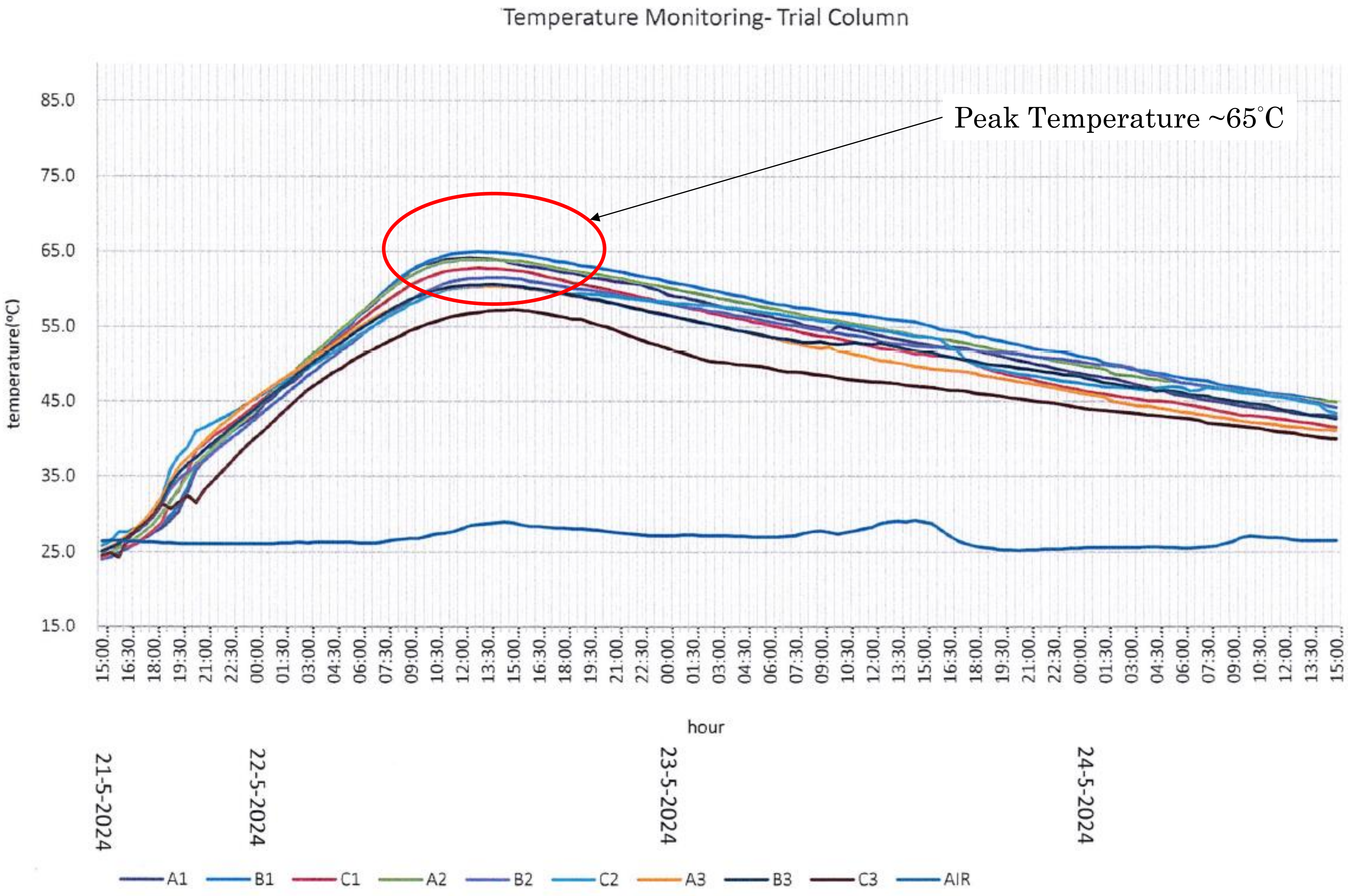
$$2C_3A + 32H_2O + 3(Ca^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}) \rightarrow C_6AS_3H_{32}$$

$$C_6AS_3H_{32} + 2C_3A \rightarrow 3C_4ASH_{12}$$

Ahmad, Jawad, et al. "A comprehensive review on the ground granulated blast furnace slag (GGBS) in concrete production." *Sustainability* 14.14 (2022): 8783.

Lower Peak Temperature

Project: Cameron Road - Temperature Rise Evaluation
Location: Trial Column
Concrete Mix: D80/20 50%GGBS+CSF TC 30°C
Test Date: 21-24/5/2024



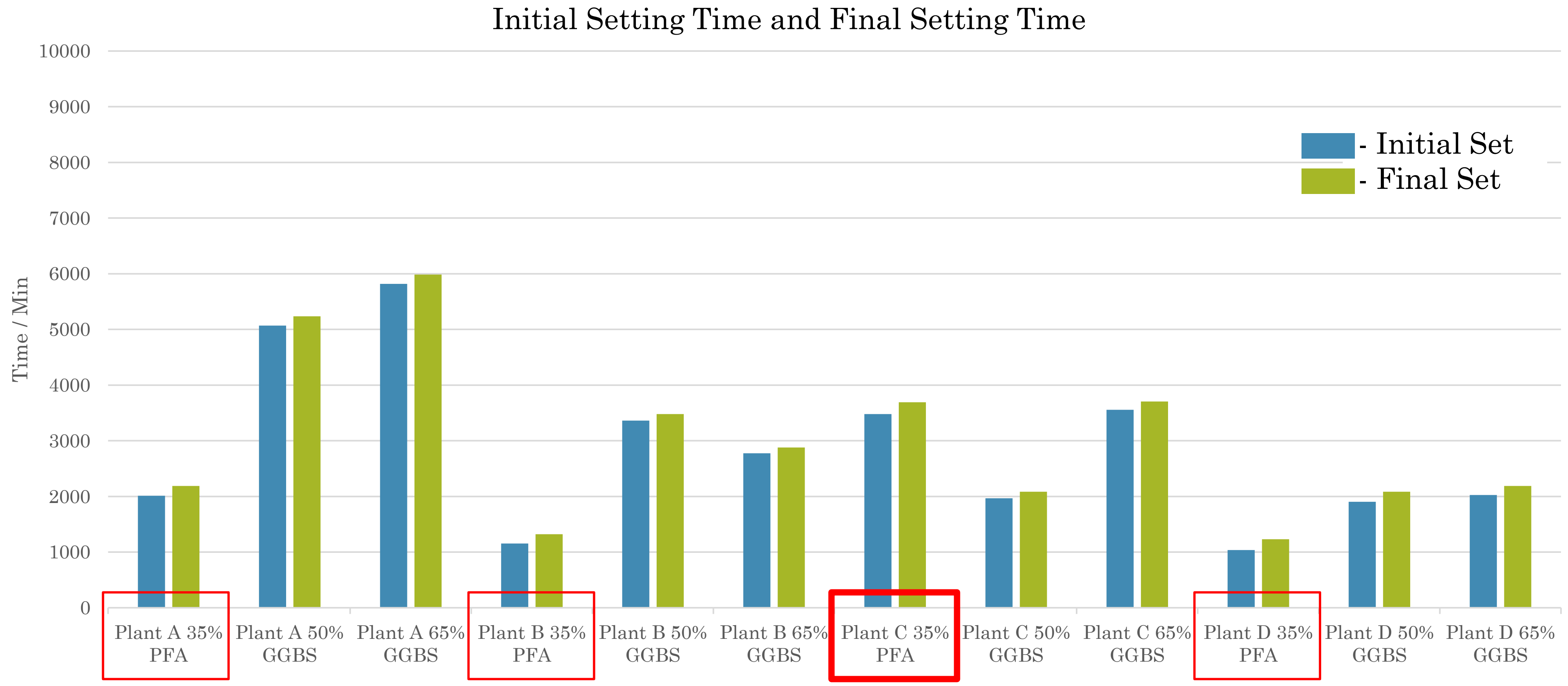
Lower Peak Temperature

D80/20 50%GGBS+CSF				
Cement	244			
GGBS	277			
CSF	33			
20 mm	670			
10 mm	315			
S/F	690			
Water	155			
w/c	0.28			
Slump Retention				
initial	220		220	
1 hr	210		205	
Compressive Strength (MPa) (150mm)				
7 Days	77.1	80.9	78.8	74.5
28 Days	86.9	87.5	88.9	86.6

Prolonged Setting Time at Fresh Stage

GGBS & PFA tremie concrete research by MTR（2024）

Setting Time



- The concrete mixes showed stiffening times exceeding 10 hours, enabling ample time for delivery and placement in tremie construction. GGBS mixes, except for plant C, displayed **longer setting times than PFA mixes**, showcasing GGBS's ability to extend setting times for tremie construction.
- These results emphasize the adaptability of GGBS mixes, underscoring the importance of adjusting admixture content to meet specific construction requirements.

Prolonged Setting Time at Fresh Stage

Bored Pile				
	D45 25%PFA	D45 60%GGBS	D60 25% PFA	D60 60%GGBS
Cement	402	184	405	200
PFA	134	0	135	0
GGBS	0	276	0	300
Water	205	200	180	200
w/c	0.38	0.43	0.33	0.40
Slump Retention				
initial	220	220	230	230
1 hr	220	220	230	230
2 hrs	210	210	220	230
10 hrs	120	150	130	160
Stiffening Time (20°C)				
Initial set (hr)	24	26	24	25
Final set (hr)	28	30	28	30
Compressive Strength (MPa)				
7 Days	45	48	59	54
28 Days	60	62	78	81

Prolonged Setting Time at Fresh Stage

Pile Cap				
	D40 35%PFA	D40 65%GGBS	D45 35%PFA	D45 65%GGBS
Cement	325	140	338	154
PFA	175	0	182	0
GGBS	0	260	0	286
Water	207	200	197	200
w/c	0.41	0.50	0.38	0.45
Slump Retention				
initial	180	180	180	180
1 hr	160	170	160	160
Stiffening Time (20°C)				
Initial set (hr)	**9**	**10**	**8**	**10**
Final set (hr)	**11**	**12**	**10**	**12**
Compressive Strength (MPa)				
7 Days	36	34	40	37
28 Days	53	55	60	62

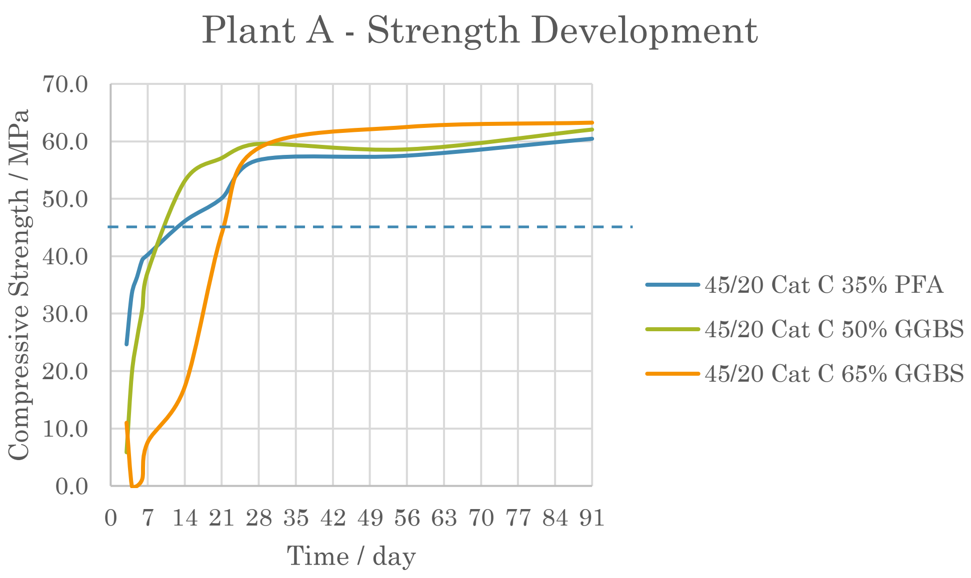
Prolonged Setting Time at Fresh Stage

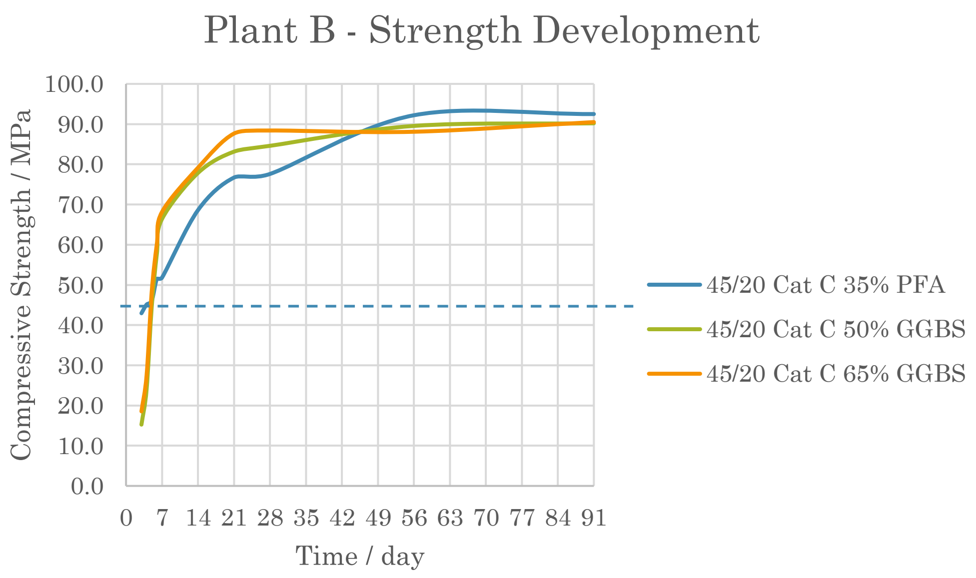
Normal Concrete						
	D45 OPC	D45 45%GGBS	D45 25% PFA	D60 OPC	D60 45%GGBS	D60 25% PFA
Cement	440	242	330	500	264	375
PFA	0	0	110	0	0	125
GGBS	0	198	0	0	216	0
Water	198	200	175	170	170	165
w/c	0.45	0.45	0.40	0.34	0.35	0.33
Slump Retention						
initial	180	180	180	220	220	220
1 hr	150	160	160	200	210	210
Stiffening Time (20°C)						
Initial set (hr)	6	8	7	6	7	6
Final set (hr)	8	10	9	7	9	8
Compressive Strength (MPa)						
7 Days	46	49	43	64	53	60
28 Days	61	67	59	81	85	77

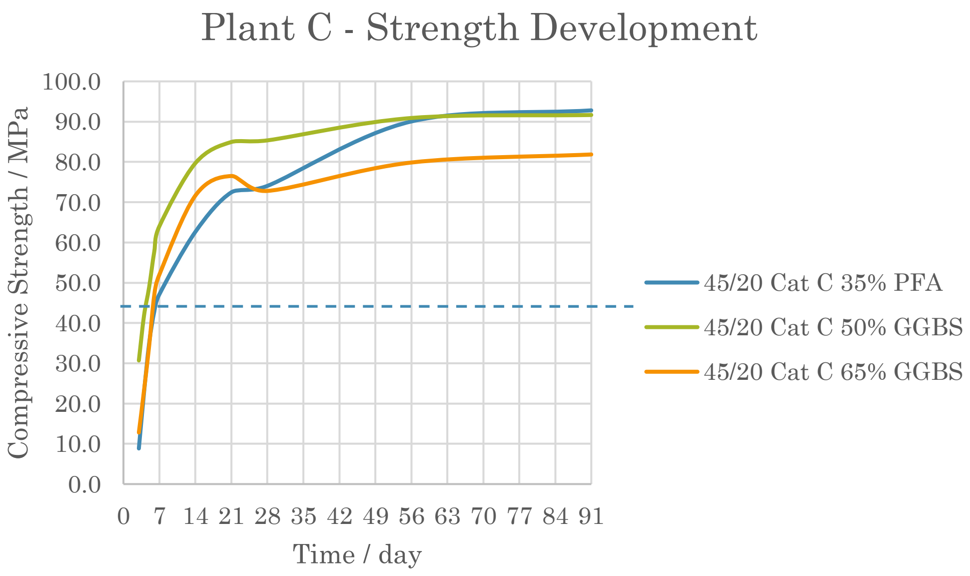
Lower Early Strength at Initial

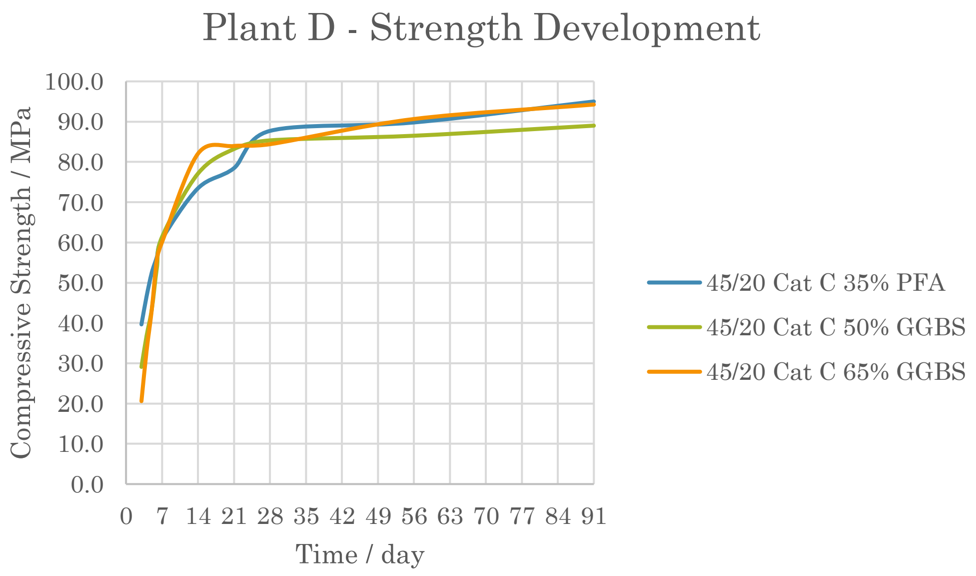
GGBS & PFA tremie concrete research by MTR

Strength Development





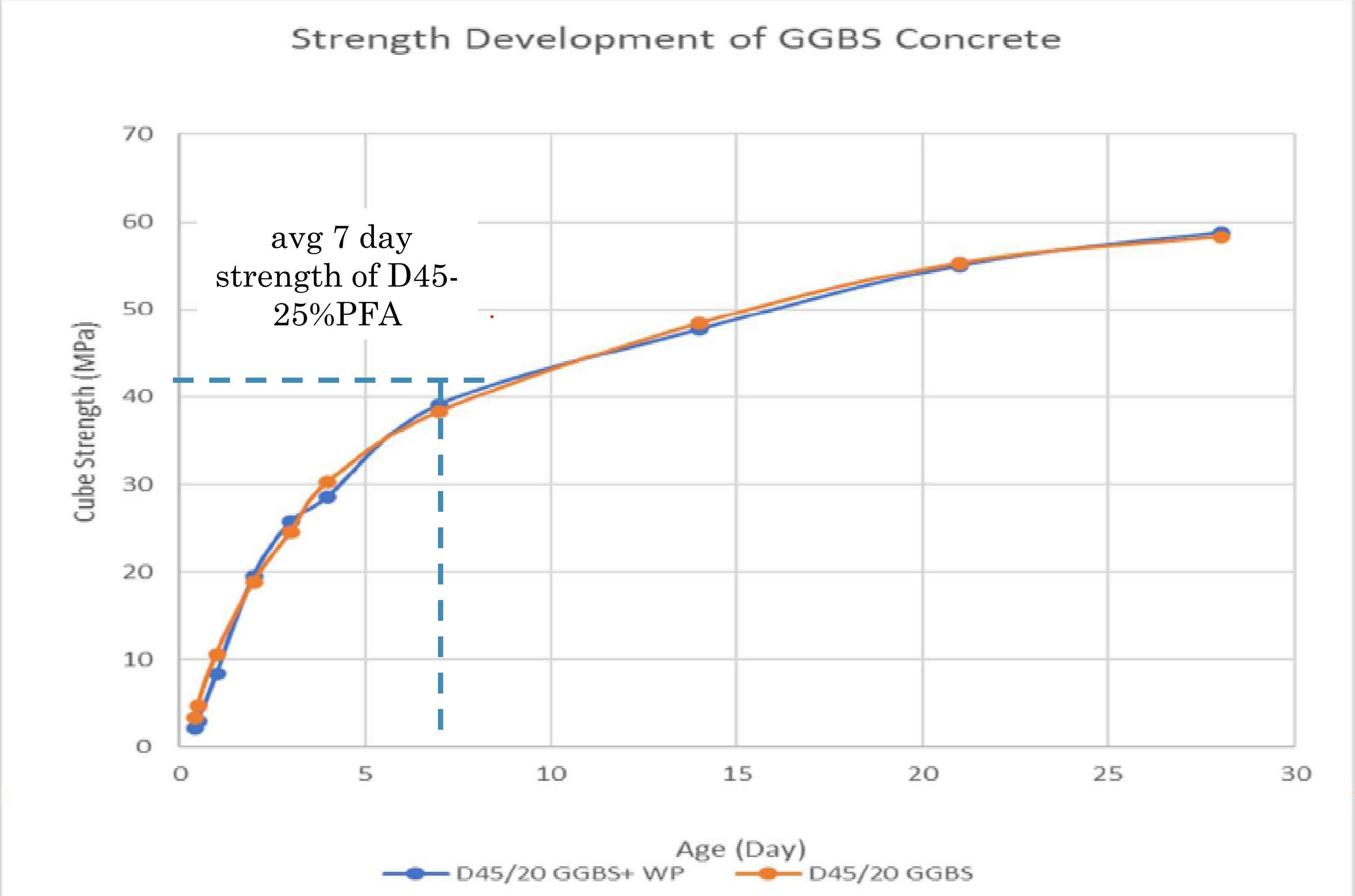


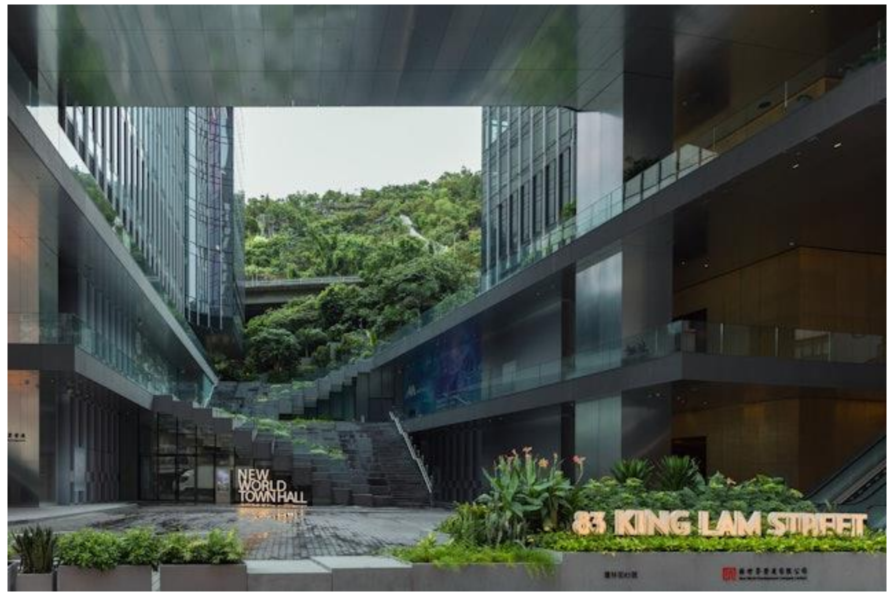


- An observable trend indicated that the initial strength of PFA mixes typically better than that of GGBS mixes, predominantly attributed to the lower dosage of 35% PFA. Strength evolution persisted up to 28 days, with marginal enhancements observed up to 91 days.
- Noteworthy the difference in strength between the 35% PFA, 50% GGBS, and 65% GGBS mixes was insignificant within each supplier.

Lower Early Strength at Initial

Mix Description	Slump	Cement	GGBS	20mm	10mm	Fine	Water	Retarder	Superplastizer	Concreteproof	A/C	W/C
D45 45%GGBS	150	242	198	610	270	800	200	2.00-4.50	2.50-4.50		3.82	0.45
D45 45%GGBS WP	150	242	198	610	270	800	200	2.00-4.50	2.50-4.50	1.54	3.82	0.45





- 17/4/2023 King Lam Street

Lower Early Strength at Initial

Mix Design – D60/20 45%GGBS

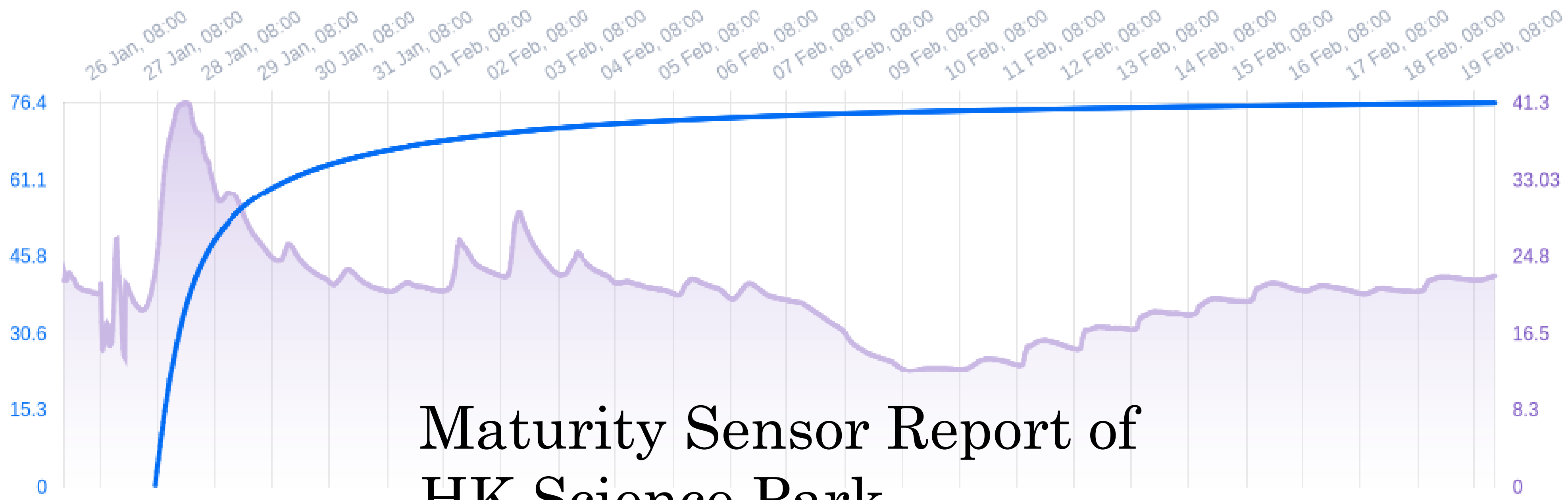
Science Park 12W-A

M/F beam / Signal 1

Report generated on Mar 12th, 2024 by Lai Chi Sing

76.4 MPa	22.7 °C	41.3 °C	12.5 °C
Compressive Strength Feb 19th, 2024, 16:36	Temperature Feb 19th, 2024, 16:36	Highest Temperature Jan 27th, 2024, 19:37	Lowest Temperature Feb 9th, 2024, 10:36

Temperature & Strength over Time



Maturity Sensor Report of HK Science Park

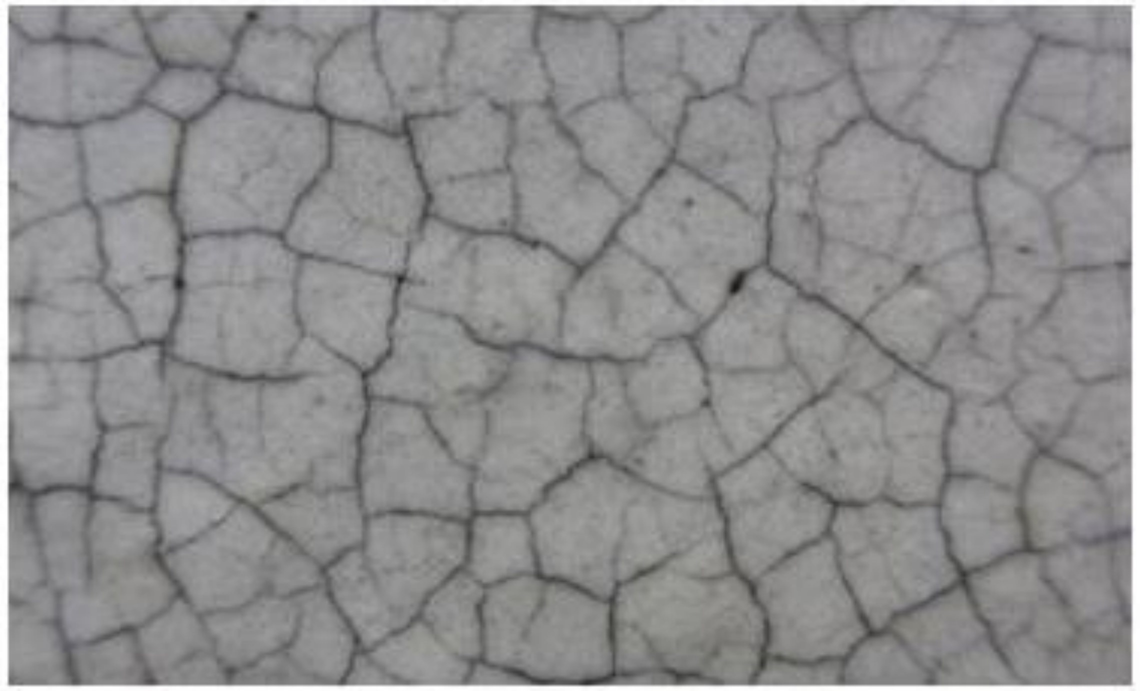
<u>3 Days to achieved designed strength</u>

Concrete Poured	Jan 26th, 2024, 19:45
30MPa	Jan 27th, 2024, 16:37
40MPa	Jan 27th, 2024, 22:37
50MPa	Jan 28th, 2024, 09:17
60MPa	Jan 29th, 2024, 10:17
Last Recorded Strength	Feb 19th, 2024, 16:36

Internal Cube Test Result Conducted in QH	
1days	**20.9/20.1**
2days	41.2/41.8
4days	**55.1/54.4**
7days	67.3/66.9
14days	75.7/73.9
21days	80.6/82.8
28days	86.7/85.0

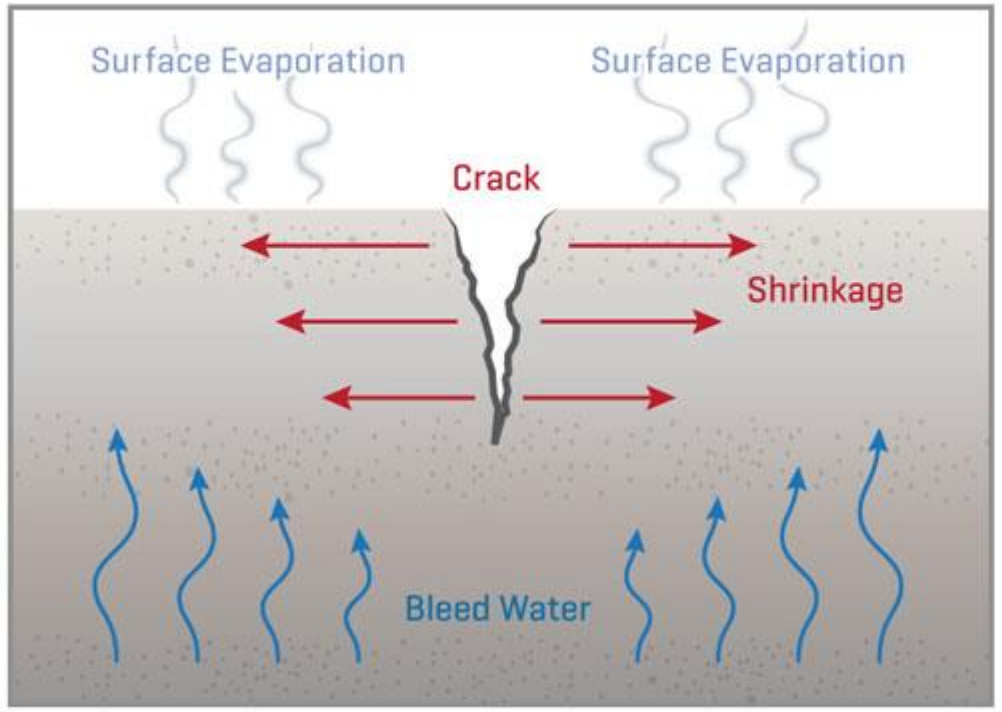
Plastic Shrinkage

- People claim early strength for concrete with GGBS is lower than that of OPC concrete, plastic shrinkage crack is prone to happen



CIVIL ENGINEERING DAILY ©

Plastic shrinkage is caused by the loss of water by evaporation from the surface of newly laid concrete or by suction of dry concrete underneath. At the surface, plastic shrinkage occurs when the rate of evaporation exceeds the rate of bleeding



Plastic Shrinkage

GGBS concrete under low temperature curing												
Concrete Grade	Compressive Strength											
	7-10°C				13-15°C				27°C			
	24 hrs	36 hrs	48 hrs	28 days	24 hrs	36 hrs	48 hrs	28 days	24 hrs	36 hrs	48 hrs	28 days
C45 Cementitious content:430 (OPC)	5	17.7	24.2	62.6	8.3	19.5	24.9	61	31.3	38.1	45.9	58.2
C45 Cementitious content:430 (OPC+25%PFA)	2.5	9.7	13.8	58.3	4.1	12.9	16.6	56.3	19	25.2	30.7	61.7
C45 Cementitious content:430 (OPC+45%GGBS)	4.7	8.5	13.4	60.6	7.4	10.1	14.2	61.6	18.6	23.4	29.5	61.5

Plastic Shrinkage

- Local curing example - Pile Cap (16/10/2024)
- Proper curing by controlling **moisture** and **temperature** of in-situ concrete
- Adequate curing should be conducted for every concrete structure to avoid plastic shrinkage

3. SUSTAINABLE CONSTRUCTION SOLUTIONS –

- ESG BENEFITS OF GGBS

ESG Benefits of GGBS

Benefits of GGBs Concrete in Environment

- Sustainability
- Recycling Materials Replacement
- Reducing Carbon Emission Factor

Reducing water permeability

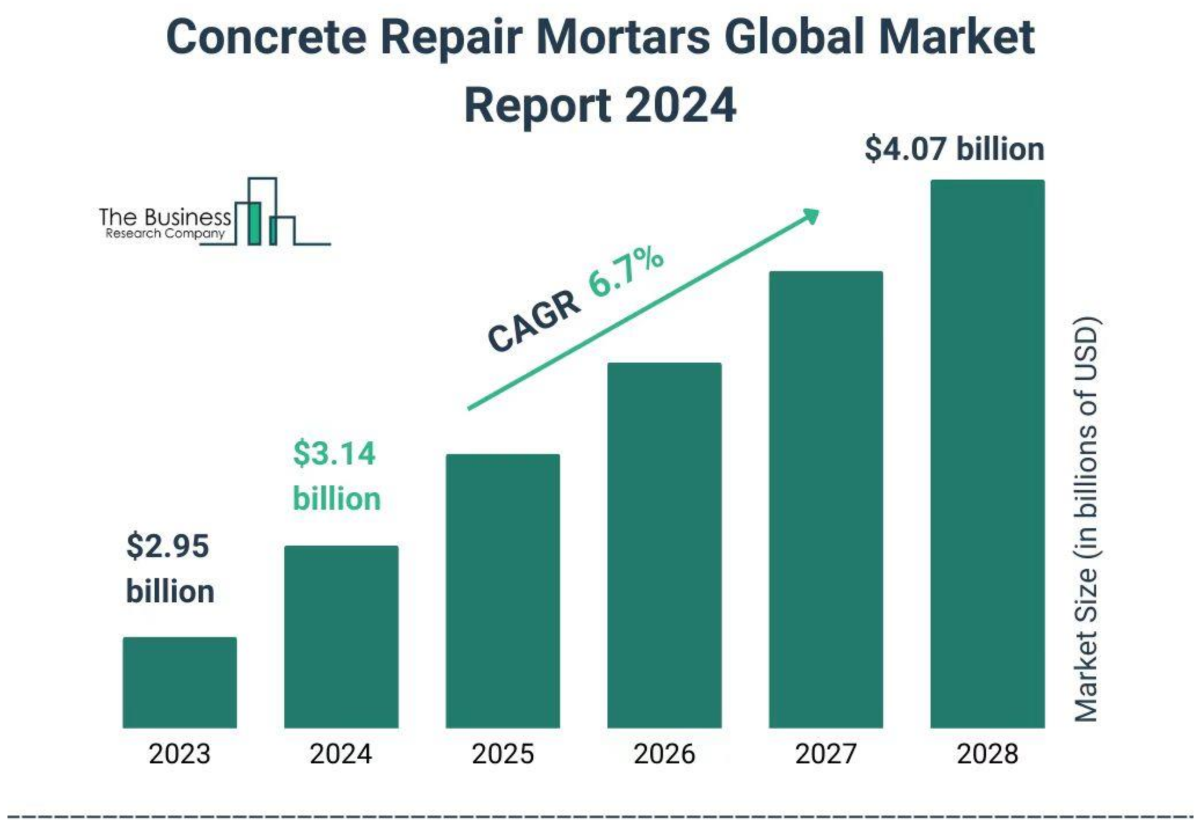
Increasing chemical resistance

Less thermal cracks

Less Life-Cycle Cost for GGBS Concrete

Enhance Concrete Durability

- Annual construction waste is expected to reach 2.2 billion tons globally by 2025

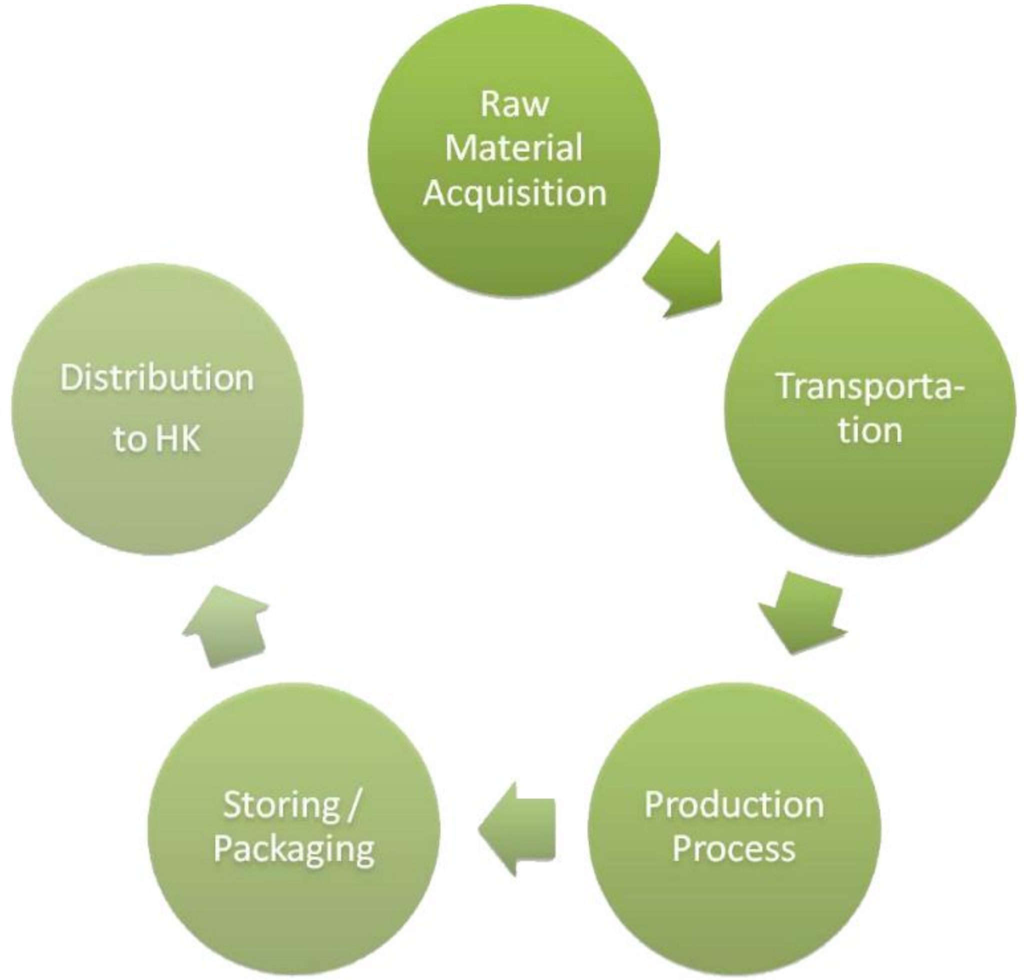


CIC Green Product Certification Introduction

Benchmark for Ready-mixed Concrete under the CIC Green Product Certification

ORIGINAL CIC Requirement:	**C30**		**C35**		**C40**		**C45**		**C50**		**C60**		**C80**	
	296		**323**		**350**		**373**		**396**		**443**		**490**	
Platinum	<	252	<	275	<	298	<	318	<	337		337		417
Gold	252	280	275	306	298	332	318	354	337	375	337	420	417	465
Silver	281	310	307	339	333	367	355	391	376	415	421	464	466	514
Bronze	311	340	340	372	368	403	392	429	416	455	465	509	515	563
Green	>	340	>	372	>	403	>	429	>	455		509		564

Carbon Assessment Method



- The quantification and reporting of the carbon footprint of products (CFP) under this Certification is thus based on a "cradle-to-site" approach, covering all GHG emissions and removals of the product arising from raw material acquisition to the border of Hong Kong.

Lower Carbon Emission Factor

Carbon footprint of Cementitious Materials

Cementitious Materials	Base Value in HK (kg CO_2/t)	Scope 1 – On-site emissions		Scope 2 – Power generation		Total (kg CO_2/t)
		Calcination of raw material	Fossil Fuel combustion	Clinker production	Grinding / Classification	
OPC	950	468	315	30	20	763
Classified PFA*	8	-			8	8
GGBS*	83	36			20	56

* Exclude the carbon emission in the primary process

產品碳足跡資訊網 Carbon Footprint Information Platform

首頁 | 碳足跡資料庫 | 碳標籤產品查詢 | 統計資訊

關鍵字: 查詢 回上一頁 資料庫使用說明 目前碳係數累計數量: 1111項

碳係數名稱	生產區域名稱	數值	宣告單位	公告年份
卜特蘭水泥(II型)	臺灣	9.81E-1 kgCO2e	公斤(kg)	2020
卜特蘭水泥(II型)	臺灣	9.64E-1 kgCO2e	公斤(kg)	2019
鋁質水泥	歐洲	1.01E+1 kgCO2e	公斤(kg)	2018
水泥熟料	臺灣	9.48E-1 kgCO2e	公斤(kg)	2017
水泥(不分型號)	臺灣	9.07E-1 kgCO2e	公斤(kg)	2017
水泥熟料	臺灣	9.50E-1 kgCO2e	公斤(kg)	2014
卜特蘭水泥(乾式)	臺灣	9.40E-1 kgCO2e	公斤(kg)	2014

Carbon emission of cement ~907kg/t

產品碳足跡資訊網 Carbon Footprint Information Platform

首頁 | 碳足跡資料庫 | 碳標籤產品查詢 | 統計資訊

預拌混凝土(245 kgf/cm2)	臺灣	2.52E+2 kgCO2e	立方公尺(m3)	2020
預拌混凝土(280 kgf/cm2)	臺灣	3.38E+2 kgCO2e	立方公尺(m3)	2020
自充填預拌混凝土(350 kgf/cm2)	臺灣	3.75E+2 kgCO2e	立方公尺(m3)	2020
預力梁用預拌混凝土(350 kgf/cm2)	臺灣	4.07E+2 kgCO2e	立方公尺(m3)	2020
早強預拌混凝土(420 kgf/cm2)	臺灣	3.70E+2 kgCO2e	立方公尺(m3)	2020
早強預拌混凝土(420kgf/cm2，飛灰爐石粉替代率22%)	臺灣	4.64E+2 kgCO2e	立方公尺(m3)	2019
早強預拌混凝土(420kgf/cm2，飛灰爐石粉替代率20%)	臺灣	4.31E+2 kgCO2e	立方公尺(m3)	2017
早強預拌混凝土(420kgf/cm2，飛灰爐石粉替代率25%)	臺灣	4.43E+2 kgCO2e	立方公尺(m3)	2017
早強預拌混凝土(420kgf/cm2，飛灰爐石粉替代率45%)	臺灣	3.36E+2 kgCO2e	立方公尺(m3)	2017
混凝土及水泥砂漿用水淬高爐爐碴粉(散裝)	臺灣	5.04E+1 kgCO2e	公噸(mt)	2016
混凝土及水泥砂漿用水淬高爐爐碴粉(太空包裝)	台灣	5.47E+1 kgCO2e	公噸(mt)	2016
飛灰爐石粉(散裝)	臺灣	4.82E+1 kgCO2e	公噸(mt)	2016
飛灰爐石粉(太空包裝)	臺灣	5.25E+1 kgCO2e	公噸(mt)	2016

Carbon emission of GGBS ~50.4kg/t

Lower Carbon Emission Factor

Carbon emission factor for concrete mix

Normal Concrete						
	D45 OPC	D45 25% PFA	D45 45%GGBS	D60 OPC	D60 25% PFA	D60 45%GGBS
Cement	440	330	242	500	375	264
PFA	0	110	0	0	125	0
GGBS	0	0	198	0	0	216
Water	198	175	200	170	165	170
w/c	0.45	0.40	0.45	0.34	0.33	0.35
Carbon Emission Factor	367.651	281.605	**226.188**	415.542	317.123	**244.564**

Bored Pile				
	D45 25%PFA	D45 60%GGBS	D60 25% PFA	D60 60%GGBS
Cement	402	184	405	200
PFA	134	0	135	0
GGBS	0	276	0	300
Water	205	200	180	200
w/c	0.38	0.43	0.33	0.40
Carbon Emission Factor	337.219	**192.514**	339.978	**207.446**

Pile Cap				
	D40 35%PFA	D40 65%GGBS	D45 35%PFA	D45 65%GGBS
Cement	325	140	338	154
PFA	175	0	182	0
GGBS	0	260	0	286
Water	207	200	197	200
w/c	0.41	0.50	0.38	0.45
Carbon Emission Factor	276.7884	**156.164**	287.0238	**169.548**

Embodied carbon reduction in concrete:
PFA concrete : ~25%
GGBS concrete : 50%+

Lower Carbon Emission Factor

D45 OPC Concrete

Manufacturer: Quon Hing Concrete Company Limited
Factory Site Address: TYTL 119, Tam Kon Shan Road, Tsing Yi, Hong Kong
Category: Ready-mixed concrete
Origin:
Carbon Rating: CIC GREEN PRODUCT CERTIFICATION gold → Bronze CIC GREEN PRODUCT CERTIFICATION
CFP Value: 327.673 kg CO_2e/m^3 product
Certificate No.: CICGPC-L-24096(RMC)
Licence End Date: 2027-11-18

Under new benchmark

D60 OPC Concrete

Manufacturer: Quon Hing Concrete Company Limited
Factory Site Address: TYTL 119, Tam Kon Shan Road, Tsing Yi, Hong Kong
Category: Ready-mixed concrete
Origin:
Carbon Rating: CIC GREEN PRODUCT CERTIFICATION gold → Bronze CIC GREEN PRODUCT CERTIFICATION
CFP Value: 373.332 kg CO_2e/m^3 product
Certificate No.: CICGPC-L-24102(RMC)
Licence End Date: 2027-11-18

Under new benchmark

D45 PFA Concrete

Manufacturer: Quon Hing Concrete Company Limited
Factory Site Address: TYTL 119, Tam Kon Shan Road, Tsing Yi, Hong Kong
Category: Ready-mixed concrete
Origin:
Carbon Rating: CIC GREEN PRODUCT CERTIFICATION platinum → Gold CIC GREEN PRODUCT CERTIFICATION
CFP Value: 261.561 kg CO_2e/m^3 product
Certificate No.: CICGPC-L-24097(RMC)
Licence End Date: 2027-11-18

Under new benchmark

D60 PFA Concrete

Manufacturer: Quon Hing Concrete Company Limited
Factory Site Address: TYTL 119, Tam Kon Shan Road, Tsing Yi, Hong Kong
Category: Ready-mixed concrete
Origin:
Carbon Rating: CIC GREEN PRODUCT CERTIFICATION platinum → Gold CIC GREEN PRODUCT CERTIFICATION
CFP Value: 292.142 kg CO_2e/m^3 product
Certificate No.: CICGPC-L-24103(RMC)
Licence End Date: 2027-11-18

Under new benchmark

D45 GGBS Concrete

Manufacturer: Quon Hing Concrete Company Limited
Factory Site Address: TYTL 119, Tam Kon Shan Road, Tsing Yi, Hong Kong
Category: Ready-mixed concrete
Origin:
Carbon Rating: CIC GREEN PRODUCT CERTIFICATION platinum
CFP Value: 202.269 kg CO_2e/m^3 product
Certificate No.: CICGPC-L-24098(RMC)
Licence End Date: 2027-11-18

D60 GGBS Concrete

Manufacturer: Quon Hing Concrete Company Limited
Factory Site Address: TYTL 119, Tam Kon Shan Road, Tsing Yi, Hong Kong
Category: Ready-mixed concrete
Origin:
Carbon Rating: CIC GREEN PRODUCT CERTIFICATION platinum
CFP Value: 219.970 kg CO_2e/m^3 product
Certificate No.: CICGPC-L-24104(RMC)
Licence End Date: 2027-11-18

ORIGINAL CIC Requirement:	C30		C35		C40		C45		C50		C60		C80	
	296		323		350		373		396		443		490	
Platinum	<	252	<	275	<	298	<	318	<	337		337		417
Gold	252	280	275	306	298	332	318	354	337	375	337	420	417	465
Silver	281	310	307	339	333	367	355	391	376	415	421	464	466	514
Bronze	311	340	340	372	368	403	392	429	416	455	465	509	515	563
Green	>	340	>	372	>	403	>	429	>	455		509		564

Proposed New Benchmarking	C30		C35		C40		C45		C50		C60		C80	
	256		279		290		293		296		323		309	
Platinum	<	218	<	238	<	247	<	250	<	252	<	246	<	263
Gold	218	242	238	264	247	275	250	278	252	280	246	306	263	293
Silver	243	268	265	293	276	304	279	307	281	310	307	338	294	324
Bronze	269	294	294	321	305	334	308	337	311	340	339	371	325	355
Green	>	294	>	321	>	334	>	337	>	340	>	371	>	356

Net-Zero emissions by 2035

Making it possible NOW

Thank you…

Old History with New Horizon ….

through Innovation *for the next stage*

4. INNOVATIVE CONSTRUCTION METHODS - Ultrafine GGBS

This is the most update Low Carbon Cement and Concrete STANDARDs

IN-LB Inch-Pound Units

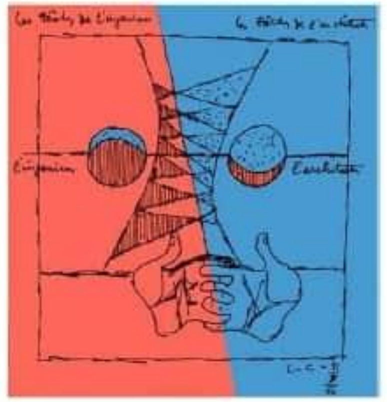
Low-Carbon Concrete—
Code Requirements and
Commentary

Reported by ACI Committee 323

ACI CODE-323-24

American Concrete Institute
Always advancing

Efficiency
Buildability
Quality



Rigidity
Strength/**L**oad
Resilience

Material
Technologies

U.S.
Low-Carbon Cement
Protocol | Version 1.0 | October 4, 2023

CLIMATE
ACTION
RESERVE

.... to be able to face these new challenges ?

Getting The Balance Right......

Independent Carbon Crediting Programmes – Low Carbon Cement Protocol

Additionality Requirement - Exceed Common Practice

Ineligible SCM/ACM List

- **Portland Limestone Cement (ASTMC595)**
- **Traditional fresh coal ash (ASTM C618)**
- **Silica fume (ASTM C1240)**
- **Traditional Slag Cement (ASTM C595 & C989)**

Grade 80 = (China S75)

Blaine- GGBS 3250cm2/g

Grade 100 = (China S95)

Blaine- GGBS 4100cm2/g

Grade 120 = (China S105)

Blaine- GGBS 5700cm2/g

ASTM - Slag Activity Index, min, %		
	Average of Last Five Consecutive Samples	Individual Sample
7-Day Index		
Grade 100	75	70
Grade 120	95	90
28-Day Index		
Grade 100	95	90
Grade 120	115	110

Eligible Products

Examples of eligible SCMs/ACMs include:

- Beneficiated coal ash (upgraded and/or harvested coal or bottom ash)
- Raw natural pozzolans (i.e., volcanic ash)
- Calcined clays/shale and/or metakaolin
- Limestone calcined clay cements (LC3)
- Carbon dioxide (CO2)
- Other artificial pozzolans or treated calcined materials (including rice husk ash)
- Other waste by-products (including Bauxite residue (Red Mud) or cement kiln dust)
- Novel ACMs (including clinkered, calcined, and non-clinkered materials)
- Hydroxide products (including portlandite (Ca(OH)2) and brucite (Mg(OH)2))
- Other novel SCM/ACM s (including biogenic limestone, etc)
- **Blends including one or more eligible SCMs/ACMs**

Project Developers

The project developer by default is the SCM/ACM supplier or manufacturer, but a project developer may also be low-carbon cement technology suppliers, and/or entities that specialize in project development.

China and India High Fineness GGBS Standard

本标准主要起草人：高春勇、姚燕、王玲、王军伟、李建勇、沈平邦、赵磊、孙继成、李增彦、王斌、高博、

ICS 91.100.30
Q 13

高强高性能混凝土用矿物外加剂

Mineral admixtures for high strength and high performance concrete

中华人民共和国国家标准

GB/T 18736—2017
代替 GB/T 18736—2002

2017 Version

表 1 矿物外加剂的技术要求

GGBS Fineness

试验项目			磨细矿渣 I	磨细矿渣 II	粉煤灰	磨细天然沸石	硅灰	偏高岭土
氧化镁（质量分数）/%		≤	14.0		—	—	—	4.0
三氧化硫（质量分数）/%		≤	4.0		3.0	—	—	1.0
烧失量（质量分数）/%		≤	3.0		5.0	—	6.0	4.0
氯离子（质量分数）/%		≤	0.06		0.06	0.06	0.10	0.06
二氧化硅（质量分数）/%		≥	—	—	—	—	85	50
三氧化二铝（质量分数）/%		≥	—	—	—	—	—	35
游离氧化钙（质量分数）/%		≤	—	—	1.0	—	—	1.0
吸铵值/(mmol/kg)		≥	—	—	—	1 000	—	—
含水率（质量分数）/%		≤	1.0		1.0	—	3.0	1.0
细度	比表面积/(m^2/kg)	≥	600	400	—	—	15 000	—
细度	45 μm 方孔筛筛余（质量分数）/%	≤	—		25.0	5.0	5.0	5.0
需水量比/%		≤	115	105	100	115	125	120
活性指数/% ≥	3 d		80	—	—	—	90	85
活性指数/% ≥	7 d		100	75	—	—	95	90
活性指数/% ≥	28 d		110	100	70	95	115	105

Table 4. Chemical characteristics of ultrafine GGBS

S. No.	Chemical component	Value (% by mass)
1	Manganese oxide (MnO)	0.45
2	Magnesium oxide (MgO)	8.91
3	Sulphide sulphur (S)	0.63
4	Sulphate (SO_4^{2-})	0.22
5	Chloride content (Cl^-)	0.07
6	CaO	33.03
7	SiO_2	33.80
8	Glass content	93.50

Table 5. Physical characteristics of GGBS

Characteristic	Value
Particle size (μm)	
D50	3.90
D95	14.21
Fineness (m^2/kg)	1822
Slag activity index %	
7 days	94.6
28 days	114
Specific gravity	2.82

Saxena, Harshit & Srivastava, Vikas & Yadav, Ashish & Tiwari, Ashok. (2024). Ultrafine GGBS and Fly Ash as Cement Replacement for Sustainable Concrete. Journal of Environmental Nanotechnology. 13. 25-30. 10.13074/jent.2024.09.242659.

GGBS Fineness And Replacement Ratio Effect On Concrete Compressive Strength

Korea Study

ID	Setting time(min) Initial	Final
Plain	255	321
HV35B1	366	455
HV35B2	371	458
HV35B3	390	491
HV35B4	396	470
HV50B1	435	556
HV50B2	414	541
HV50B3	415	530
HV50B4	442	560
HV65B1	330	645
HV65B2	375	652
HV65B3	345	825
HV65B4	581	748
HV80B1	205	1105
HV80B2	255	1105
HV80B3	365	1140
HV80B4	385	735

ID		Unit weight(kg) water	OPC	GB1	GB2	GB3	GB4
0%	Plain	2.4	12.0	-	-	-	-
35%	HV35B1	2.4	7.8	4.2	-	-	-
	HV35B2	2.4	7.8	-	4.2	-	-
	HV35B3	2.4	7.8	-	-	4.2	-
	HV35B4	2.4	7.8	-	-	-	4.2
50%	HV50B1	2.4	6	6	-	-	-
	HV50B2	2.4	6	-	6	-	-
	HV50B3	2.4	6	-	-	6	-
	HV50B4	2.4	6	-	-	-	6
65%	HV65B1	2.4	4.2	7.8	-	-	-
	HV65B2	2.4	4.2	-	7.8	-	-
	HV65B3	2.4	4.2	-	-	7.8	-
	HV65B4	2.4	4.2	-	-	-	7.8
80%	HV80B1	2.4	2.4	9.6	-	-	-
	HV80B2	2.4	2.4	-	9.6	-	-
	HV80B3	2.4	2.4	-	-	9.6	-
	HV80B4	2.4	2.4	-	-	-	9.6

GGBS Fineness and Replacement Ratio On Concrete Compressive Strength At Water/Binder Ratio = 0.24

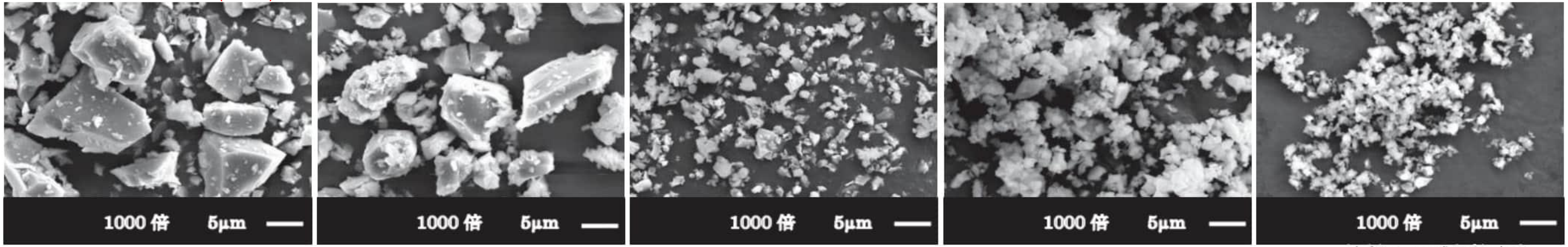
Blaine B1=4,350 cm^2/g, **Blaine B2=5,350** cm^2/g, **Blaine B3=6,450** cm^2/g, **Blaine B4=7,650** cm^2/g,

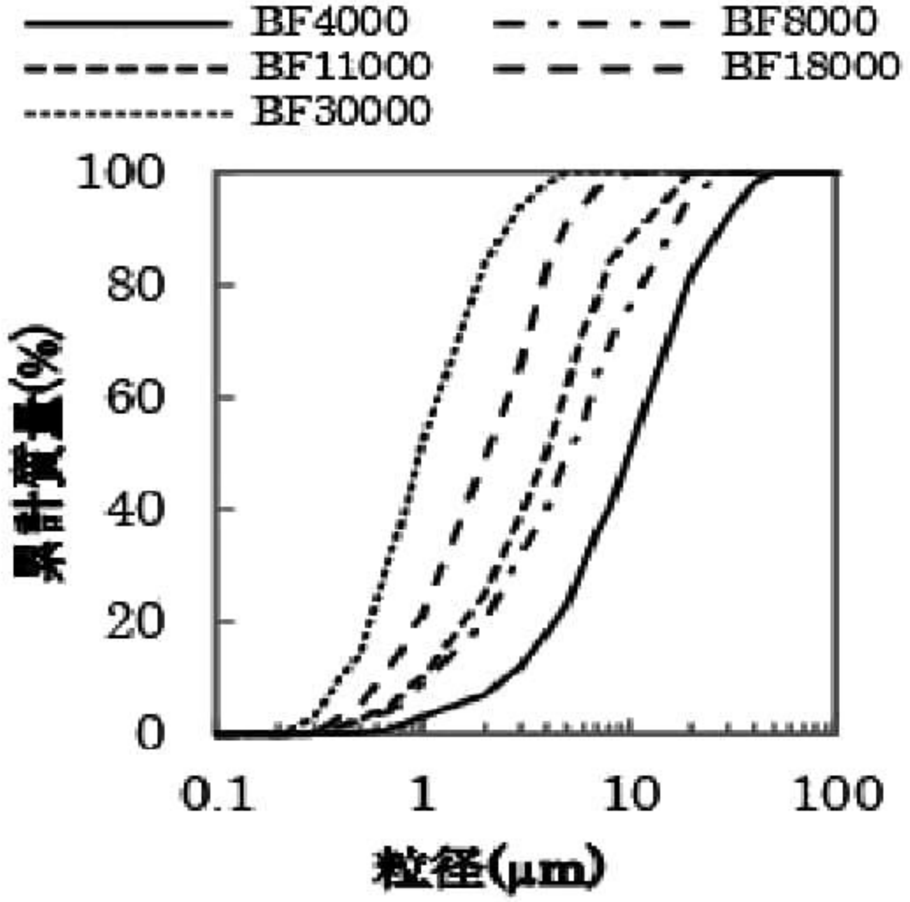
GGBS Replacement		ID	Flow (mm)	Compressive Strength (MPa) 3 day	7 day	28 day	91 day
		Plain	202.0	**82.0**	**91.9**	**107.3**	**131.3**
35%	Blaine B1~B4	HV 35 B1	415.0	87.2	104.2	136.7	152.5
		HV 35 B2	411.5	90.5	110.7	141.2	151.5
		HV 35 B3	405.5	88.1	113.4	136.5	153.9
		HV 35 B4	363.0	**95.4**	**111.2**	**142.5**	**154.7**
50%	Blaine B1~B4	HV 50 B1	424.5	78.3	111.9	142.5	157.2
		HV 50 B2	425.0	86.6	112.6	145.8	158.3
		HV 50 B3	410.0	90.7	114.6	144.2	156.1
		HV 50 B4	366.0	**92.7**	**112.0**	**123.7**	**154.5**
65%	Blaine B1~B4	HV 65 B1	458.5	75.3	126.0	142.2	163.7
		HV 65 B2	442.0	80.2	119.8	128.0	155.0
		HV 65 B3	436.0	78.5	117.5	128.0	142.6
		HV 65 B4	407.0	**82.8**	**118.4**	**131.9**	**149.0**
80%	Blaine B1~B4	HV 80 B1	441.5	60.7	109.4	118.1	125.7
		HV 80 B2	448.0	68.1	114.7	121.5	138.2
		HV 80 B3	453.5	70.3	117.9	119.3	136.2
		HV 80 B4	412.0	**78.6**	**97.7**	**113.1**	**121.0**

Japan GGBS Slag Activity Index And Blaine Fineness

各種高炉スラグ微粉末の SEM 画像

BF4000 (S95) | BF8000 | BF11000 | BF18000 | BF30000





高炉スラグ微粉末の種類および物性

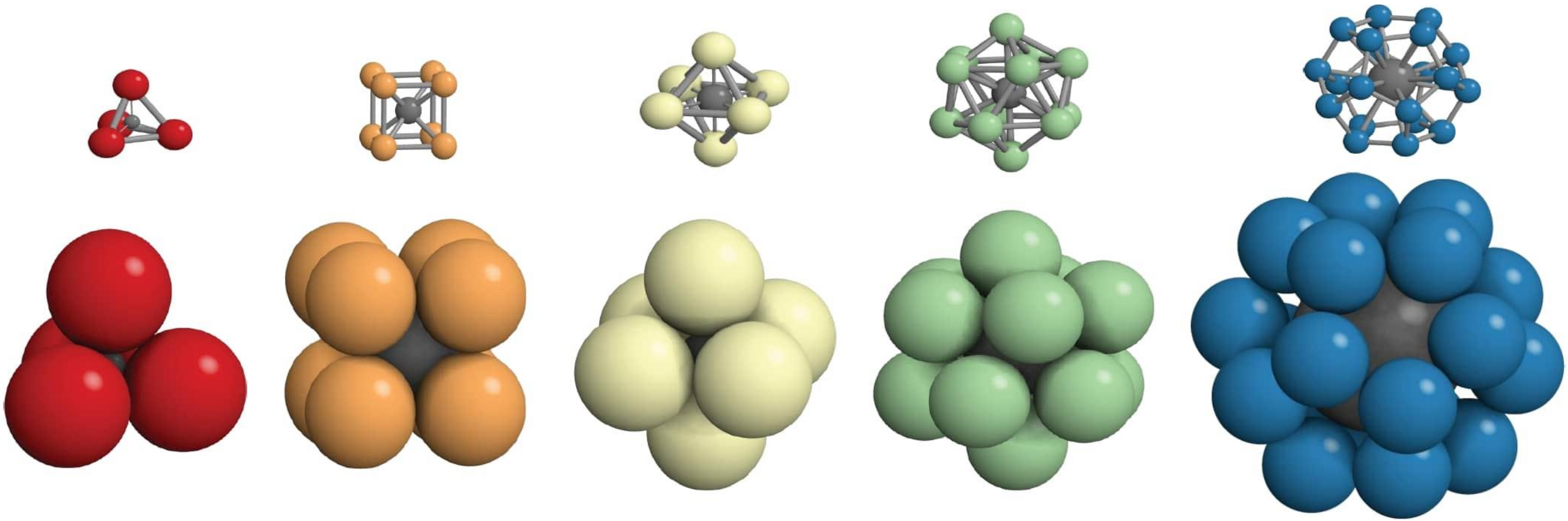
Production Using Air Classifier		種類				
		BF4000	BF8000	BF11000	BF18000	BF30000
密度(g/cm^3)		2.92	2.92	2.92	2.92	2.92
比表面積(cm^2/g)		4830	8180	10800	18050	29620
平均粒径(μm)		9.6	5.2	4.0	2.0	1.0
フロー値比(%)		100	99	98	93	86
活性度指数(%)	7日	67	98	100	154	164
	28日	99	112	128	138	138
	91日	105	120	122	118	111

高炉スラグ微粉末の化学成分

化学成分(%)	試験値	JIS A 6206の規定値
ig.loss	0.55	3.0 以下
insol	0.64	—
SiO_2	32.7	—
Al_2O_3	13.4	—
Fe_2O_3	0.5	—
CaO	41.6	—
Na_2O	0.22	-
K_2O	0.28	-
MgO	6.9	10 以下
SO_3	0.34	4.0 以下
Cl^-	0.0003	0.02 以下

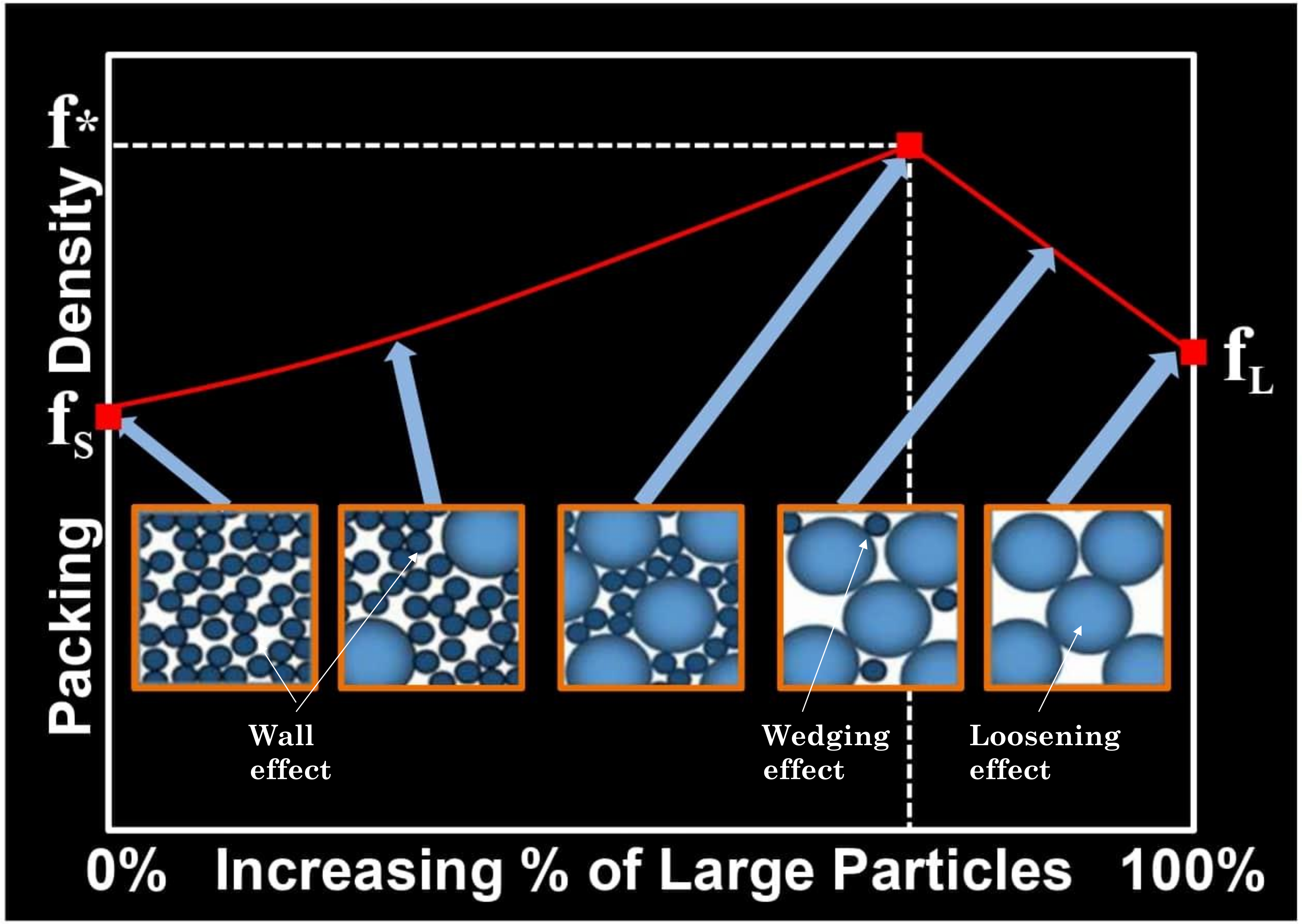
NEXT Expanding Cement Paste Property Space

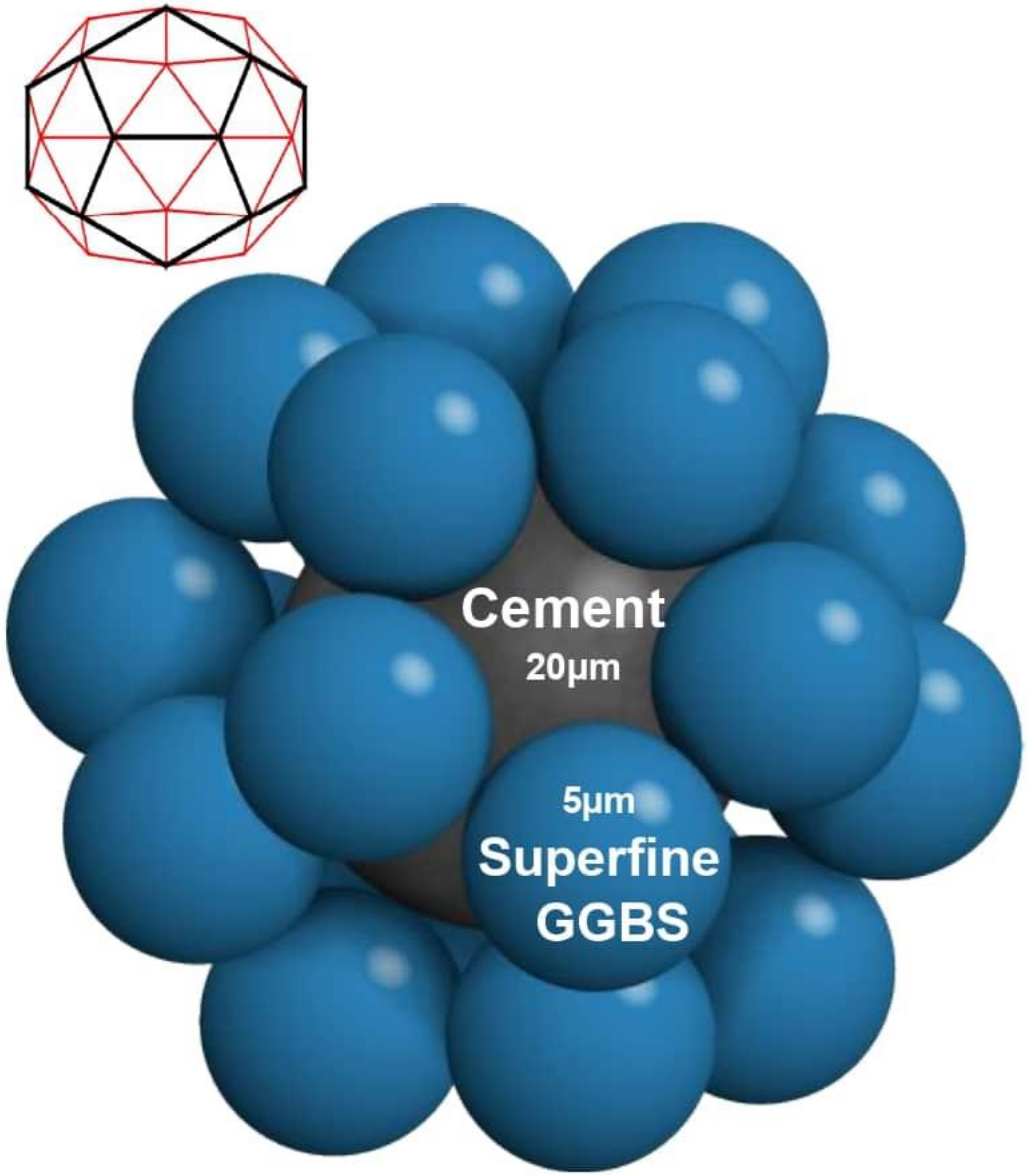
Concept of Packing Density



Filler Effect Occupying Effect

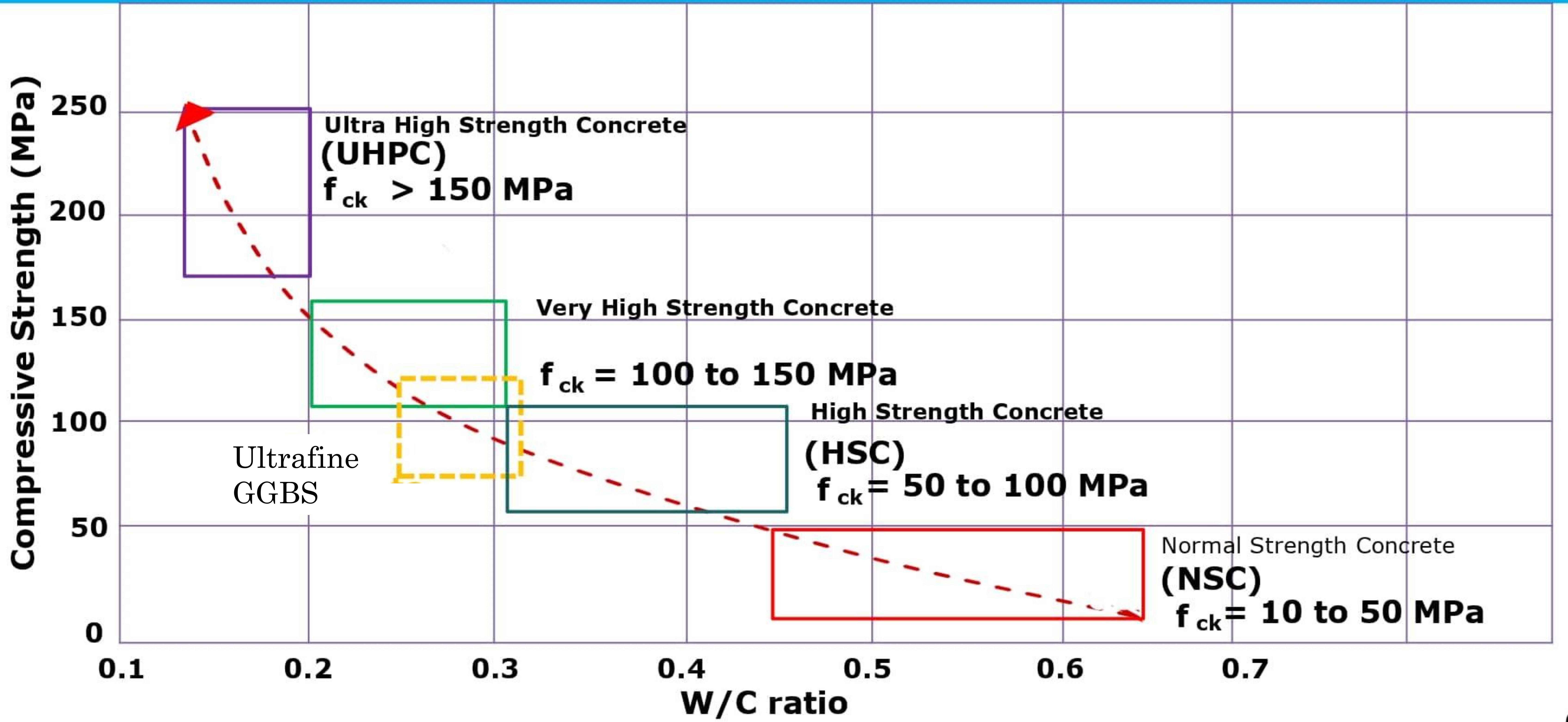
Tailoring Bimodal Local Packing Density





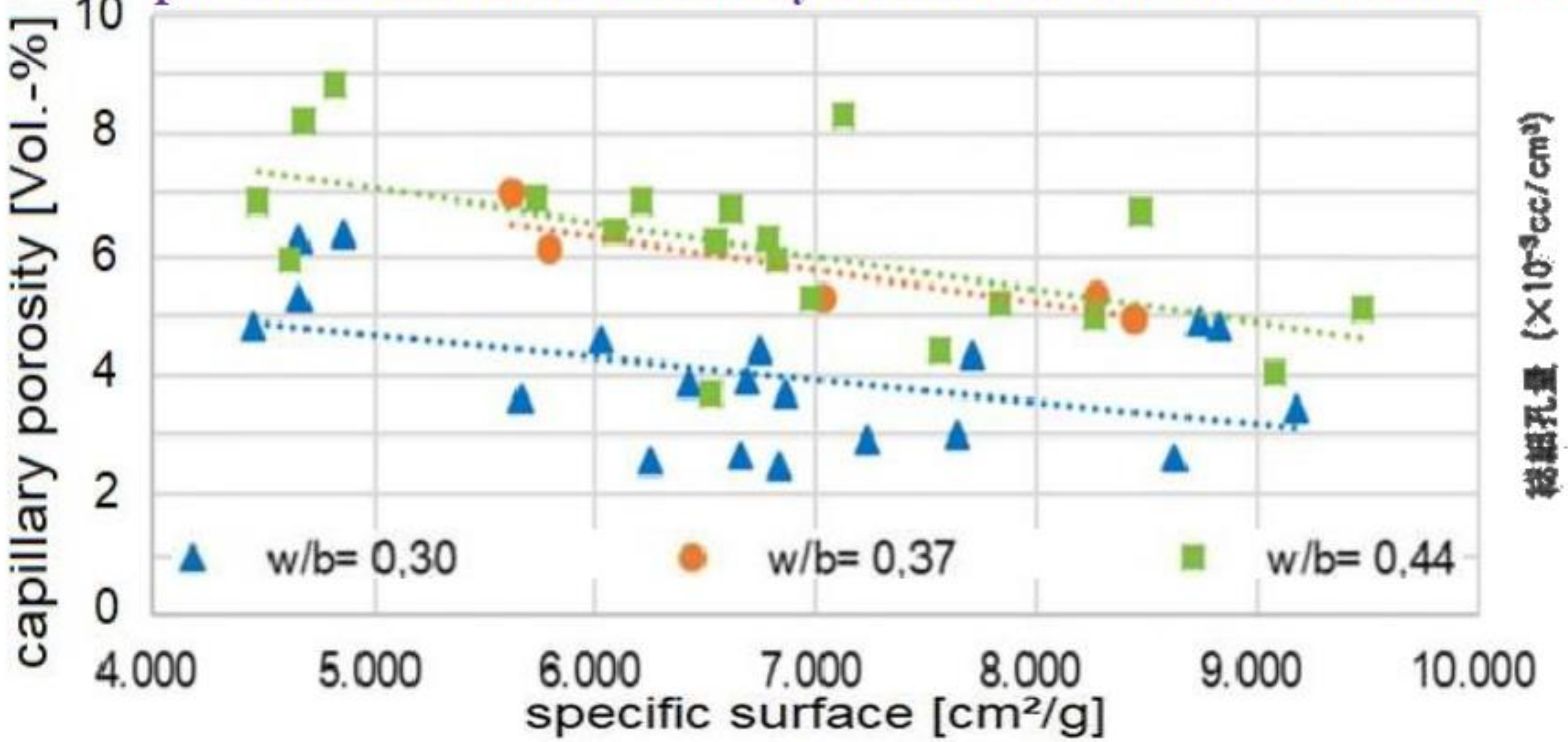
Adv of High Fineness GGBS

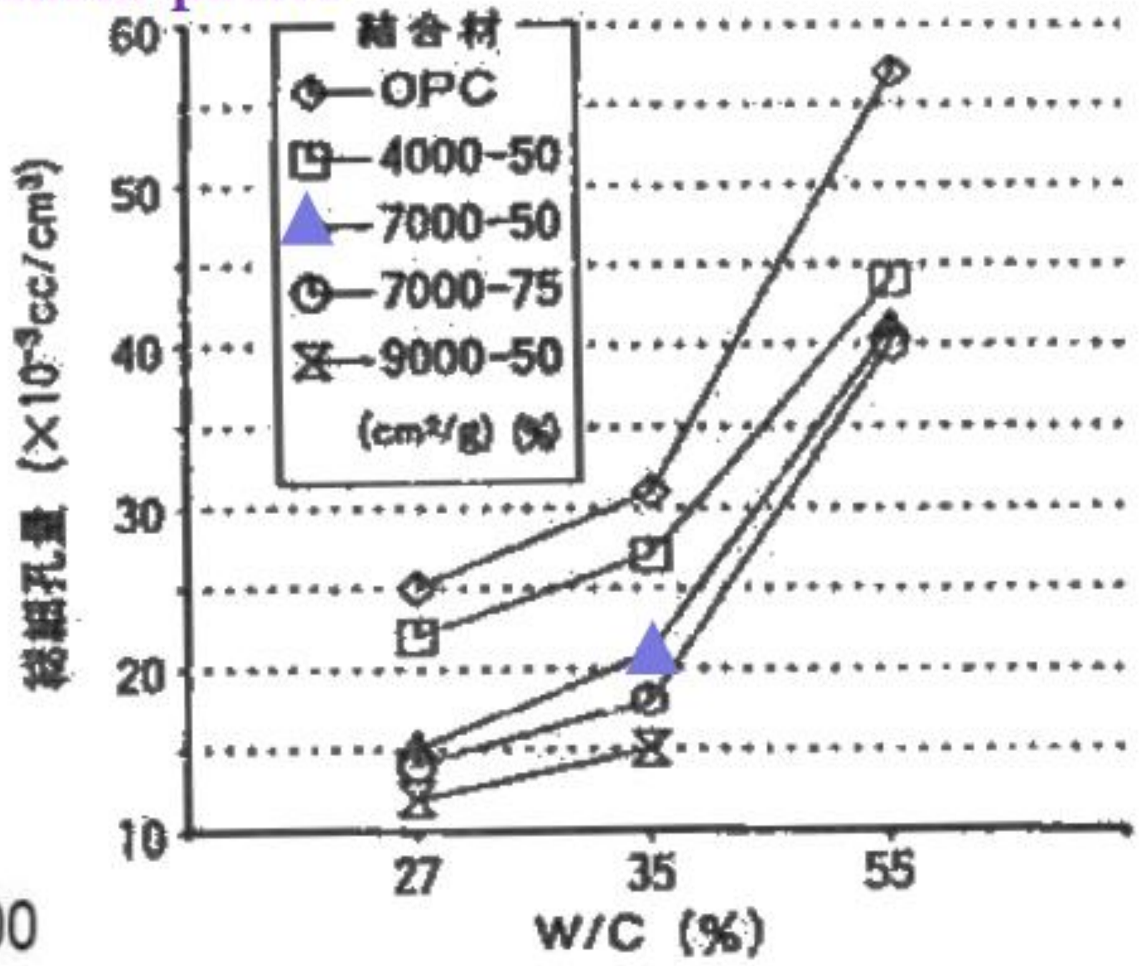
CONCRETE PERFORMANCE push continuously upwards



2. High Fineness GGBS Capillary Pore Size

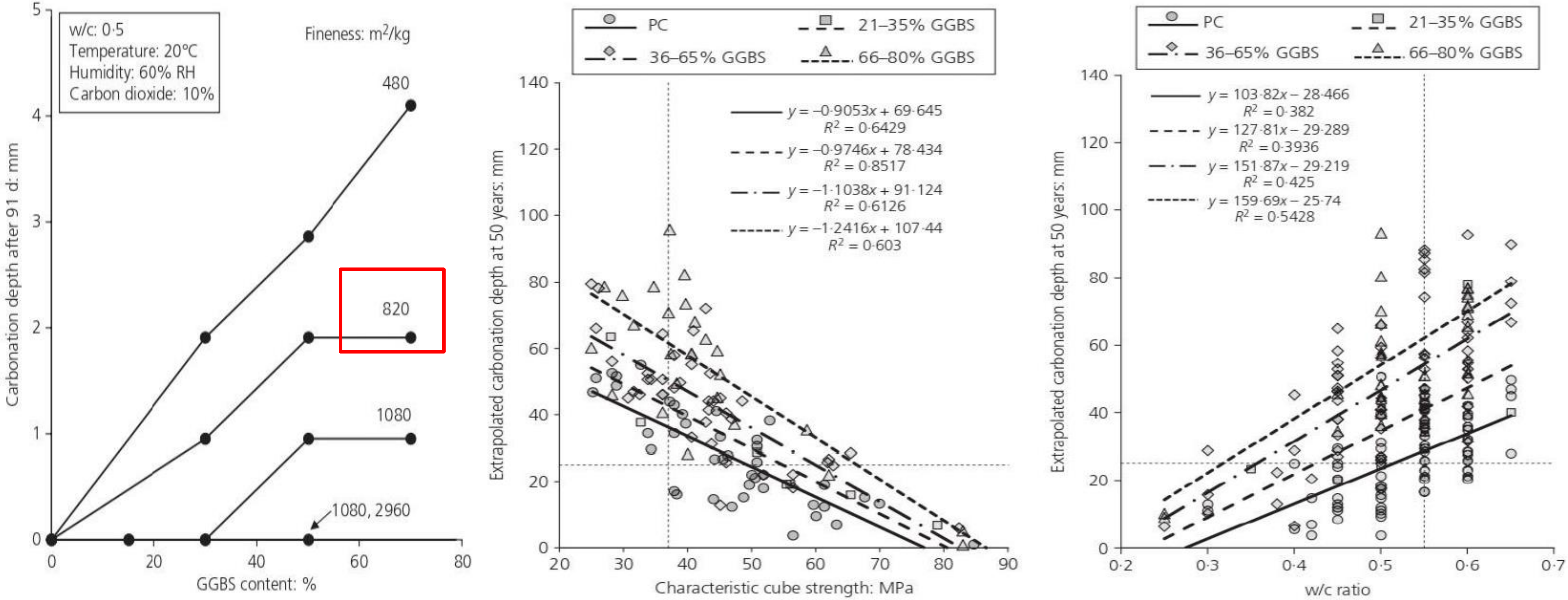
High (ultra-fine) granulated blast furnace slag content has a favourable effect both on the capillary/gel pore ratio and on the calcium hydroxide content in the hardened cement paste.





Impact of w/b ratio and specific surface on the capillary porosity

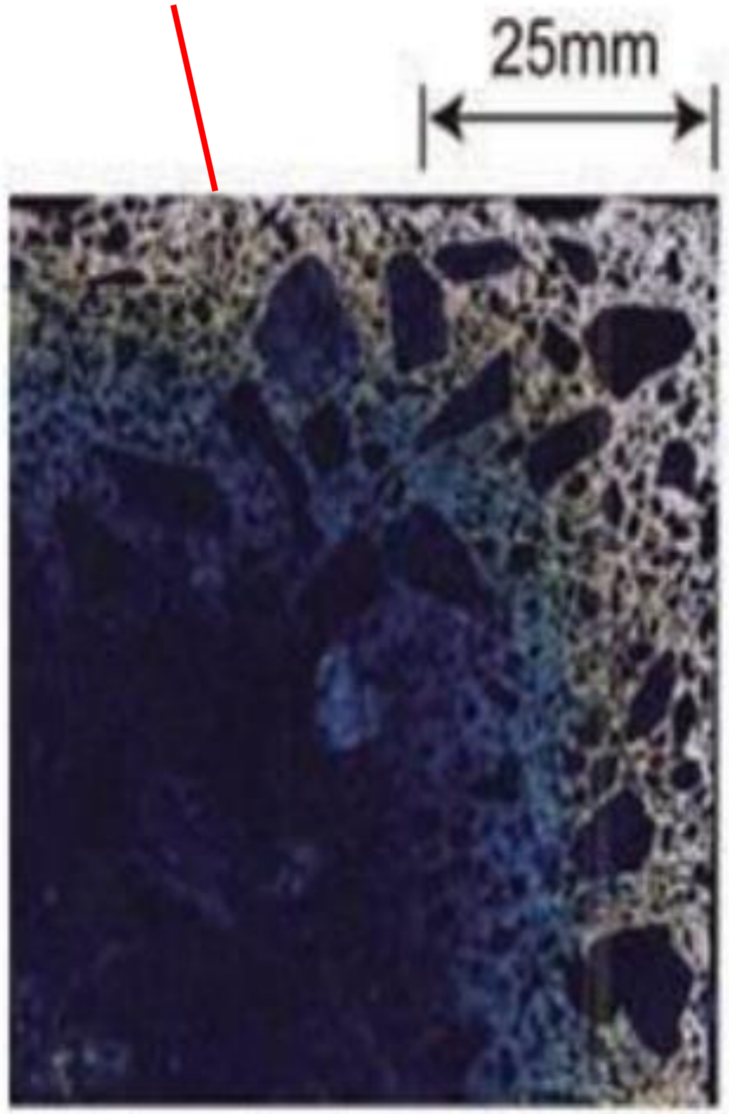
3. High Fineness GGBS Carbonation Resistance



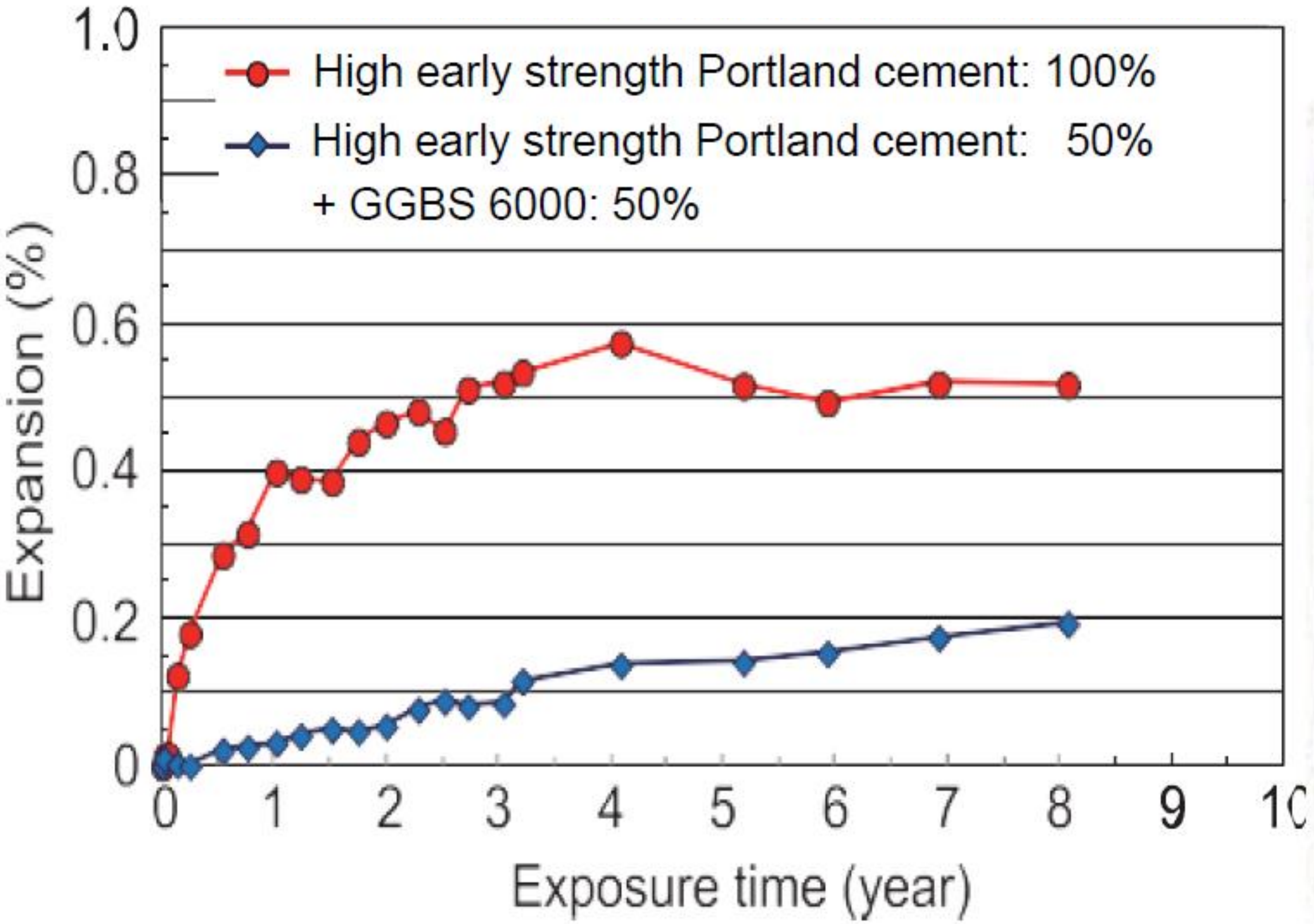
Slag %, Slag Fineness, Compressive Strength and W/B ratio on Carbonation Depth

4. High Fineness GGBS ASR Resistance

Carbonated concrete

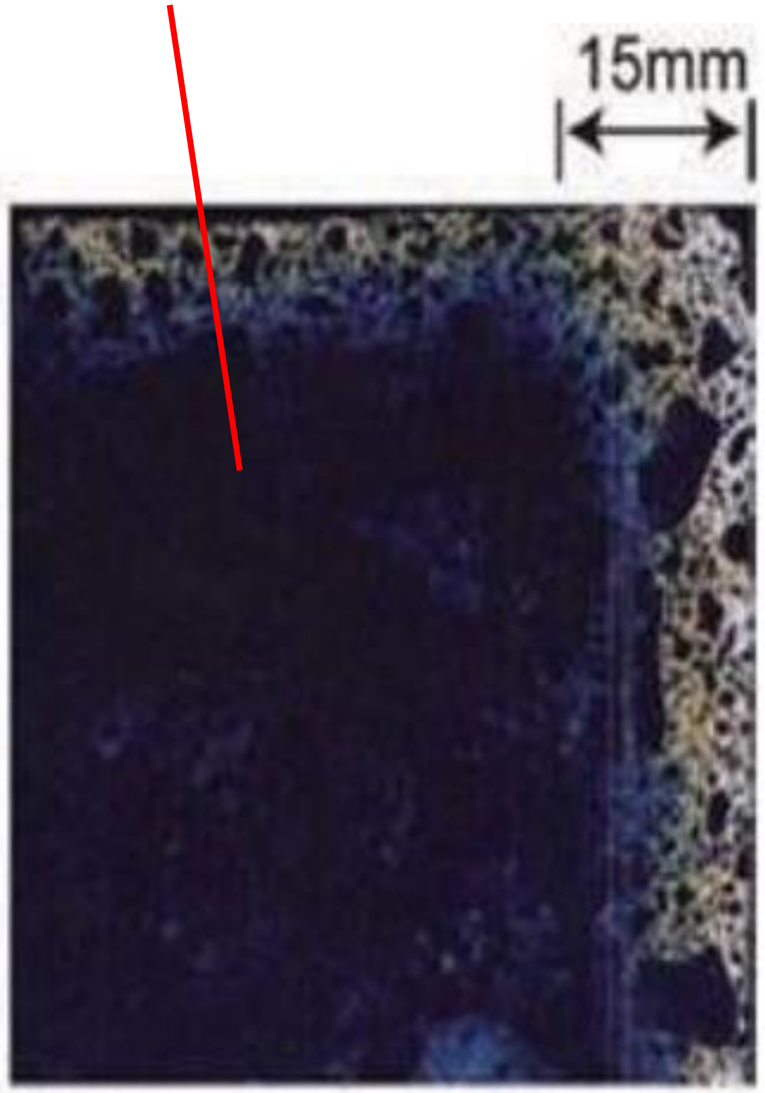


High early strength
Portland cement: 100%



ASR expansion of PC beam made with reactive aggregate

Sound concrete



High early strength
Portland cement: 50%
+ GGBS 6000: 50%

Adv of High Fineness GGBS

Superfine GGBS Fineness and Substitution Rate On Concrete Properties

	Type	S 95 GGBS 4000			Ground granulated blast-furnace slag 6000		
	Blaine specific surface area (cm^2/g)	3000	≦	< 5000	5000	≦	< 7000
	Substitution ratio (%)	35	50	70	35	50	70
Property of fresh concrete	Fluidity	○	○	○	◎	◎	◎
	Bleeding	○	○	△	◎	◎	◎
	Setting delay effect	◎	◎	◎	◎	◎	◎
	Adiabatic temperature rise	–	–	◎	–	–	◎
	Heat generation rate restraint	○	◎	◎	○	○	◎
Property of strength	Initial strength	○	△	△	○	○	△
	28 days strength	○	○	△	○	◎	◎
	Long-term strength	○	◎	◎	○	◎	◎
	High strength	○	△	△	○	◎	◎
Property of durability	Drying shrinkage	○	○	○	○	○	○
	Carbonation	–	–	△	–	–	△
	Freeze thaw	○	○	○	○	○	○
	Water-tightness	○	◎	◎	○	◎	◎
	Salt shield	○	◎	◎	○	◎	◎
	Seawater resistant	○	◎	◎	○	◎	◎
	Acid and sulfates resistant	○	◎	◎	○	◎	◎
	Heat resistant	○	○	○	○	○	○
	Alkali-silica restraint	○	◎	◎	○	◎	◎
	Abrasion resistance	○	○	○	○	○	◎

Legend:
◎ : Good property is provided in comparison with no mixture concrete.
△ : Attention is necessary for use.
○ : At the same level or a little good property is provided.
– : Property varies according to a condition.

G.Seed IP Protected Innovation

Intellectual Property Assets

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WO2024065340

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WO2023082040

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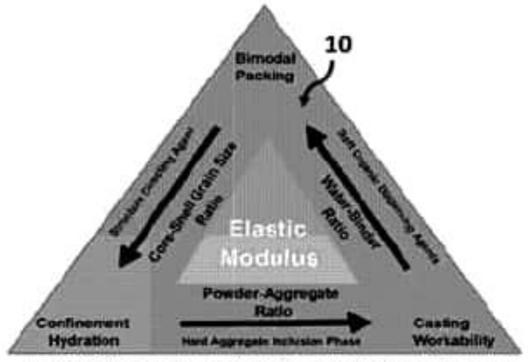
(71) **Applicant: FLEXCRETE TECHNOLOGY LIMITED** [CN/CN]; Unit 6, 15/F., Tower 1, Ever Gain Plaza, 88 Container Port Road, Kwai Chung, New Territories, Hong Kong (CN).

(74) **Agent: RUNPING & PARTNERS**; Suite 515, Yingu Mansion, No.9 Beisihuanxilu, Haidian District, Beijing 100190 (CN).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,

(54) **Title:** HARMONIC-STRUCTURED HYDRAULIC BINDER, MANUFACTURING METHOD THEREOF AND STRENGTH-DECOUPLED HIGH ELASTIC MODULUS CEMENTITIOUS COMPOSITE MATERIAL MADE USING THE SAME.



Cyclic design procedure for strength-decoupled high elastic modulus concrete

FIG. 7c

(57) **Abstract:** A novel strength-decoupled high elastic modulus cementitious composite (10), and a novel harmonic-structured hydraulic binder compositions (11). The compositions (11) comprise an effective amount of bimodal coarse (21) and ultrafine hydraulic particles (27) forming core-shell self-assembled clusters matrix. The cementitious composite (10) elements show substancial improved elastic modulus and durability material properties, particularly towards structural deformation and sustainability.

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[Continued on next page]

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(71) **Applicant: FLEXCRETE TECHNOLOGY LIMITED** [CN/CN]; Unit 6, 15/F., Tower 1, Ever Gain Plaza, 88 Container Port Road, Kwai Chung, New Territories, Hong Kong (CN).

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Published:
— *with international search report (Art. 21(3))*
— *with amended claims and statement (Art. 19(1))*

(54) **Title:** ELASTIC REINFORCED COMPOSITE FOR FORMING DIVERSE STRUCTURAL SYSTEMS AND ITS APPLICATION IN MONOLITHIC SANDWICH MATERIAL COMPOSITE

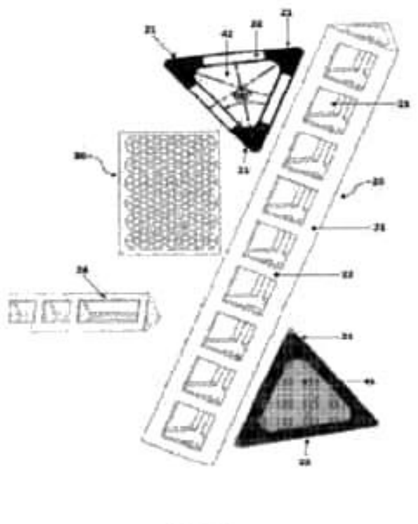


Figure 4

(57) **Abstract:** Fabrication and design of novel reinforced cementitious composite (10) made up of seamless elongate monolithic perforated tabular metallic reinforcement bar (20) with triangular sectional confinement topology configured by three continuous parallel aligned interconnected solid rod-like portion located at triangular apexes respectively as longitudinal reinforcing phase (21), multiple perforated mid-span shell bandage as anchorage phase (22), and infiltrated heterogeneous blend tunable low hydration heat high elastic modulus hydraulic binder material as matrix phase (40) characterized by an unique, core-radial, axial-align, distributed mechanical bond anchorage dowel network (41) effected from multi-cellular matrix dowel unit cells (42) synergistically formed unitarily with endless cellular confinement hoops along the perforated mid-span shell during hydraulic binder composite solidification and its use therewith multi-layer perforated metallic plates as transversal reinforcing phase (30) for fabricating diverse three-dimensional reinforcement bar network confinement cage in constructing reinforced solid concrete elements of buildings and civil structures.

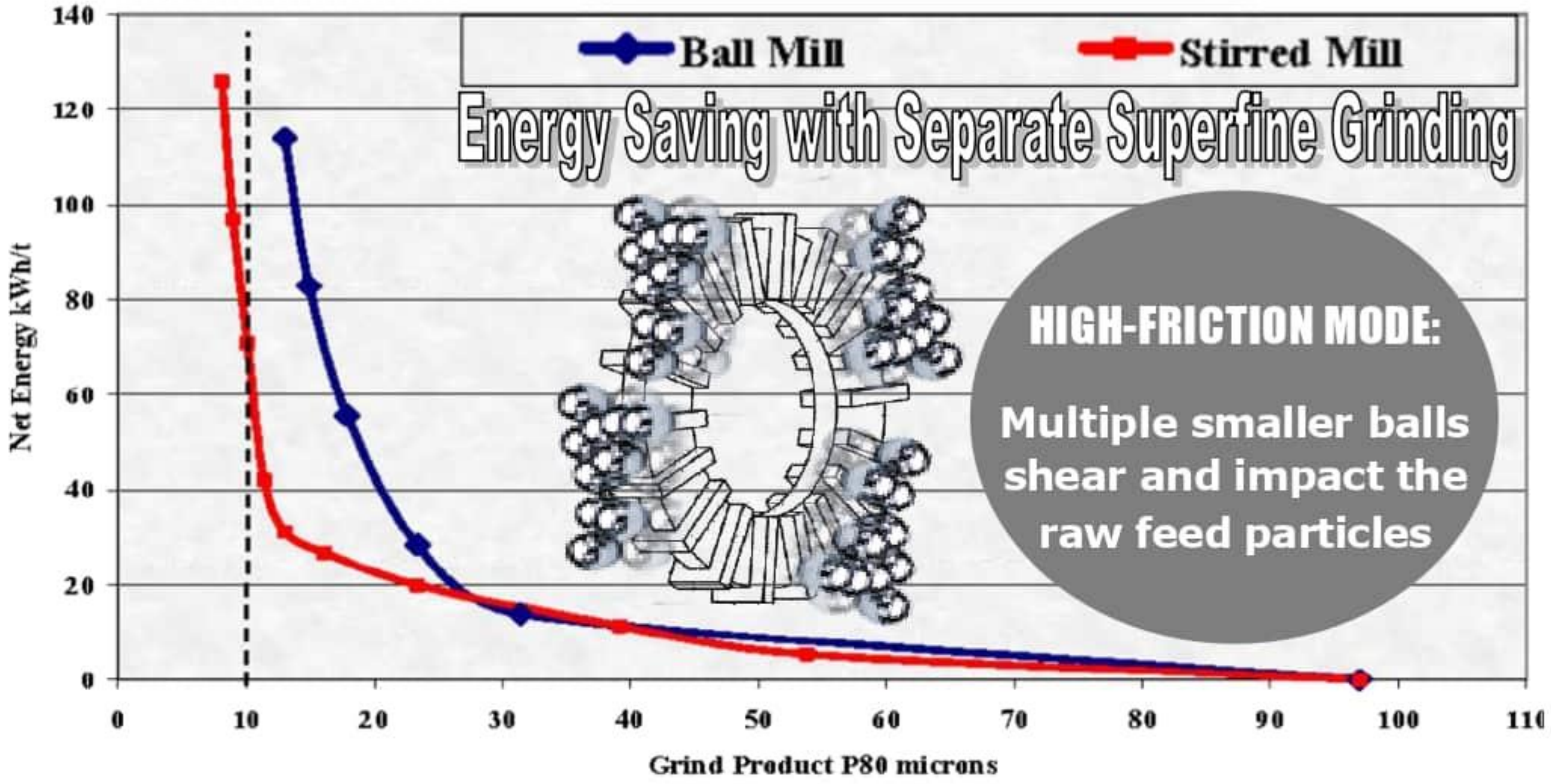
WO 2023/082040 A1

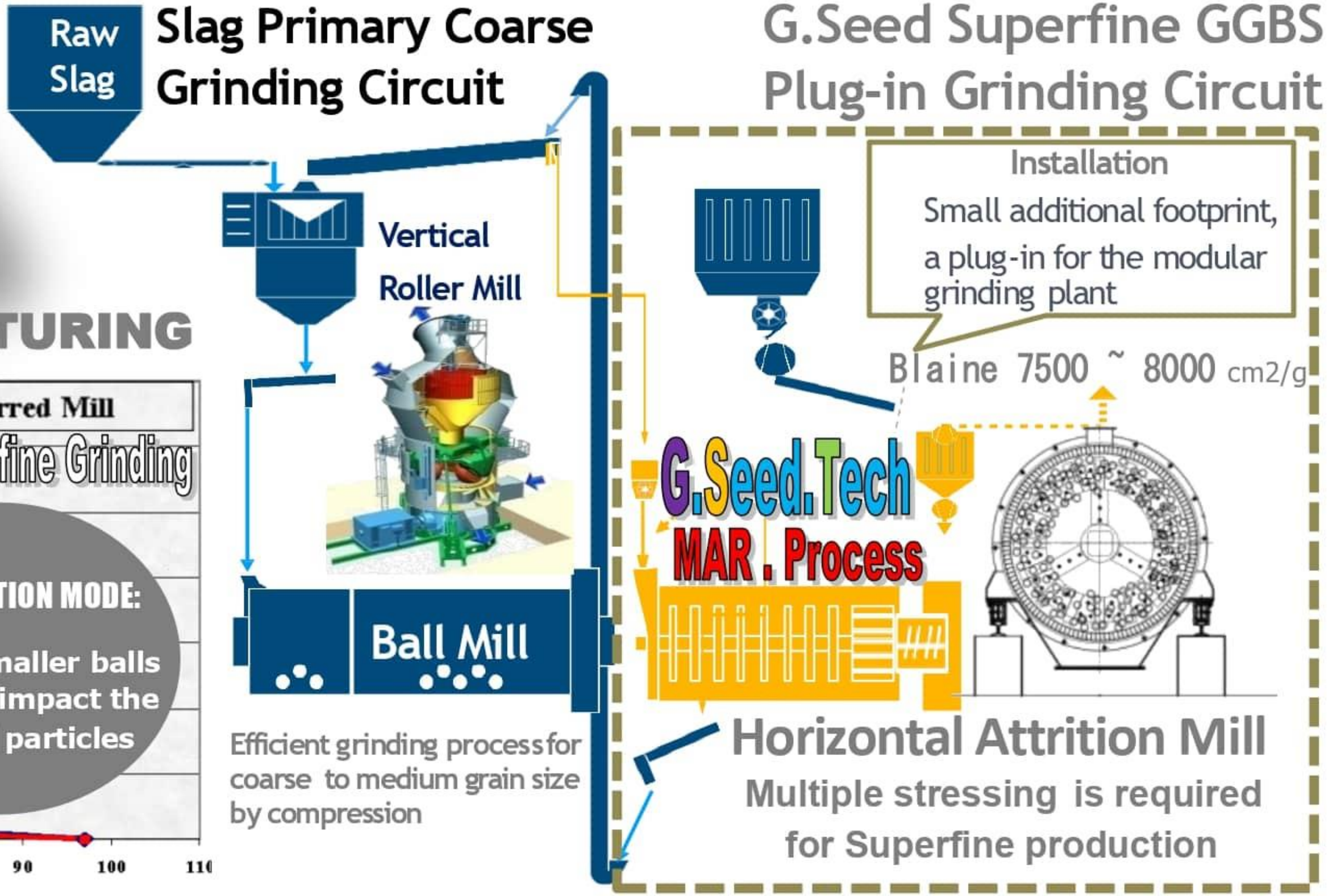
MARMILL

Our Innovative Grinding Approach

G.Seed Superfine GGBS

Eligible SCM.MANUFACTURING

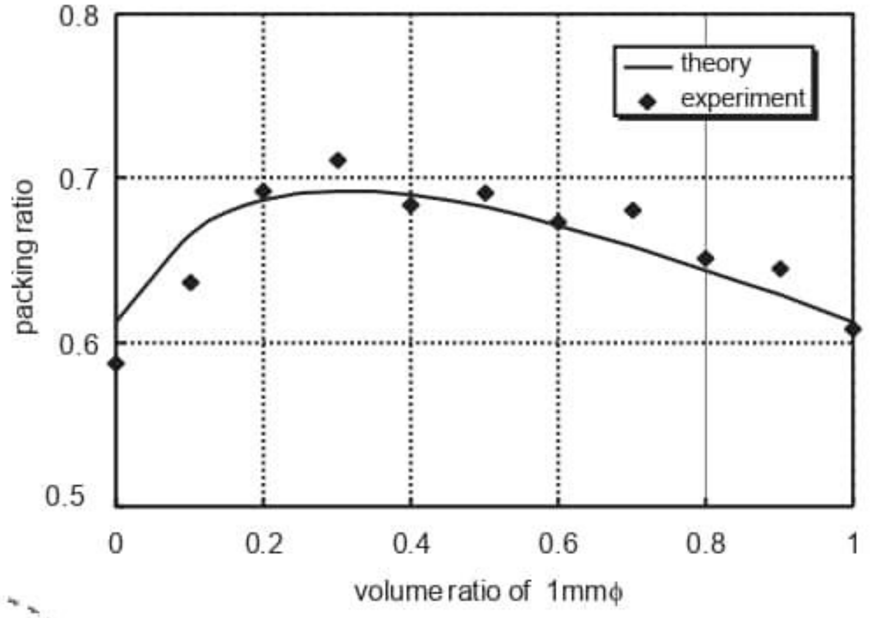




Novel Agitator | Horizontal Dry Grinding | Non-Classifier | Continuous Mode

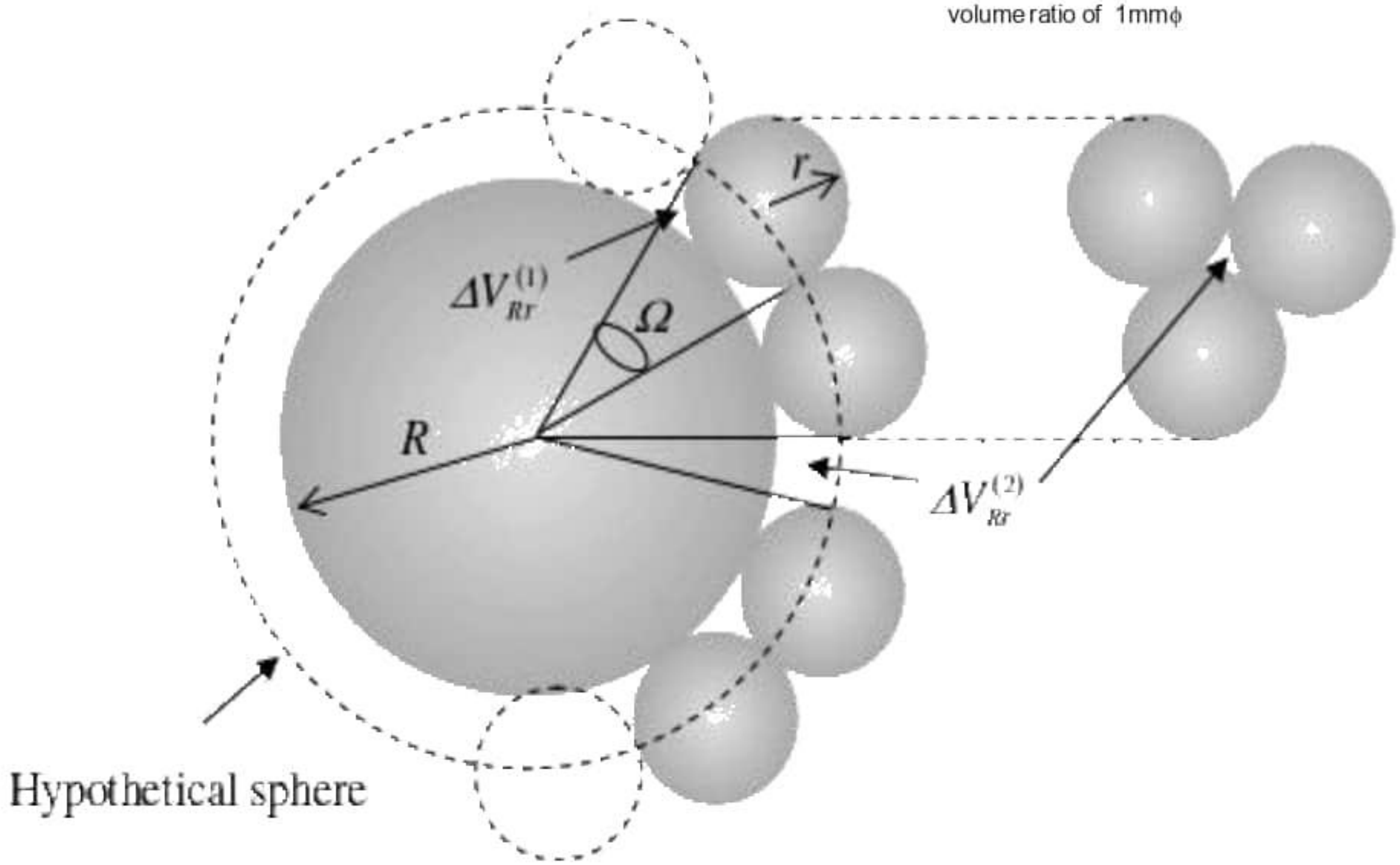
Core-Shell Microstructure – Local Dense Packing

Simple system consisting of single type of particles (5mmϕ)



Packing density of mixed-particle system comprising particles with two different radii.

The horizontal axis represents the volume ratio of particle diameter of 1 mm.



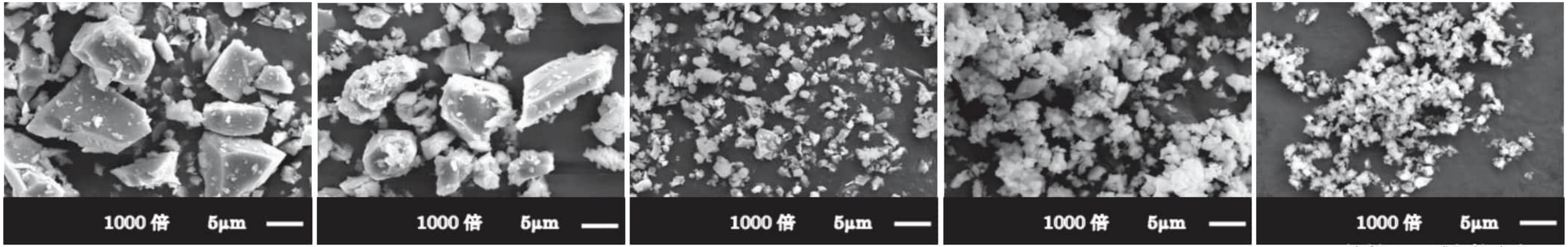
Packing of spheres with radius *r* in direct contact with sphere with radius *R*.

System with particles having two different diameters particles (1mmϕ : 5mmϕ =3 : 7)

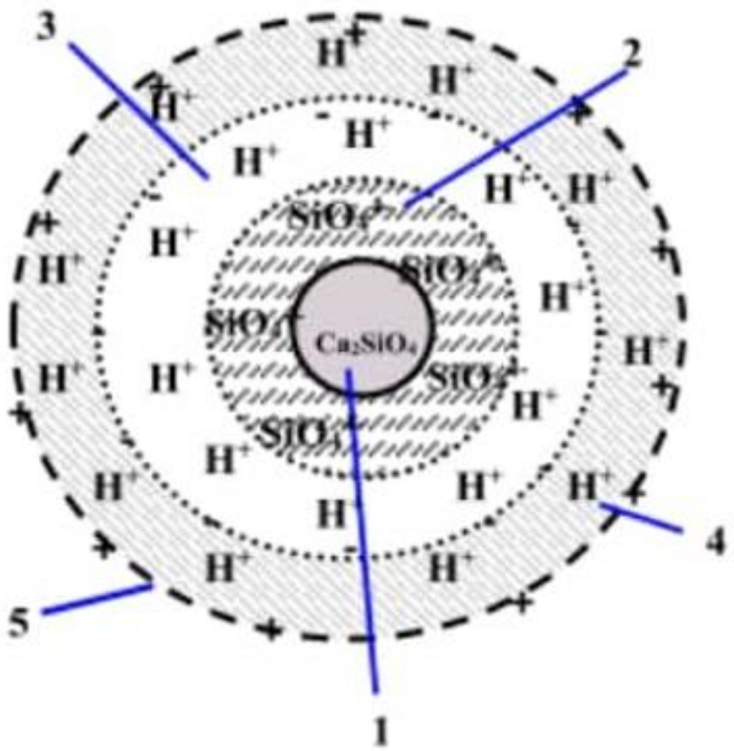
Japan GGBS Slag Activity Index And Blaine Fineness

各種高炉スラグ微粉末の SEM 画像

BF4000 BF8000 BF11000 BF18000 BF30000



BF4000 – – – – BF8000
BF11000 – – – – BF18000
BF30000



高炉スラグ微粉末の種類および物性

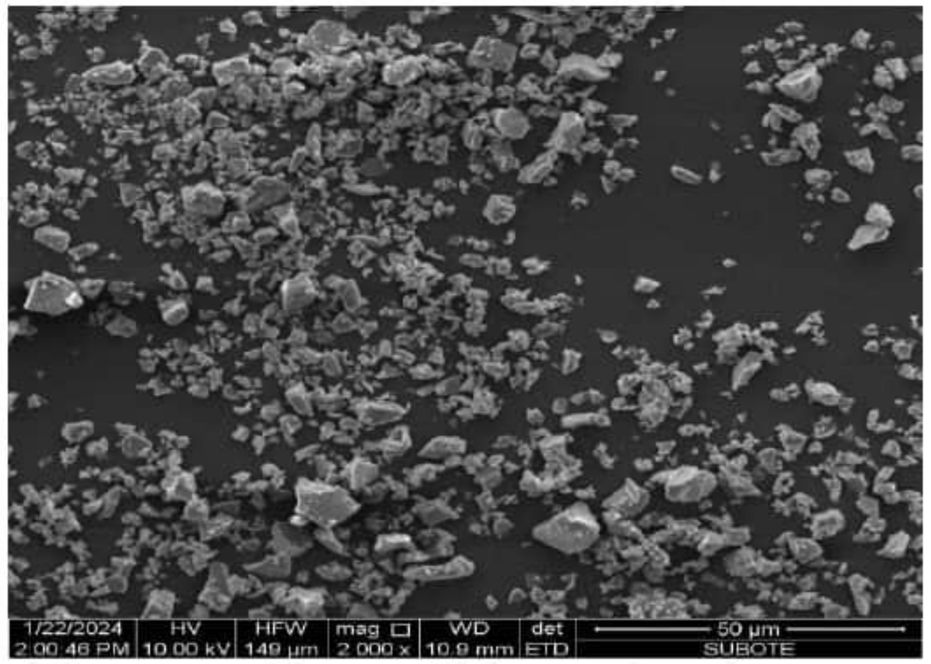
Production Using Air Classifier		種類					
		BF4000	BF8000	BF11000	G.Seed	BF18000	BF30000
密度(g/cm^3)		2.92	2.92	2.92		2.92	2.92
比表面積(cm^2/g)		4830	8180	10800		18050	29620
平均粒径(μm)		9.6	5.2	4.0		2.0	1.0
フロー値比(%)		100	99	98		93	86
活性度指数(%)	7日	67	98	100	110	154	164
	28日	99	112	128	140	138	138
	91日	105	120	122		118	111

高炉スラグ微粉末の化学成分

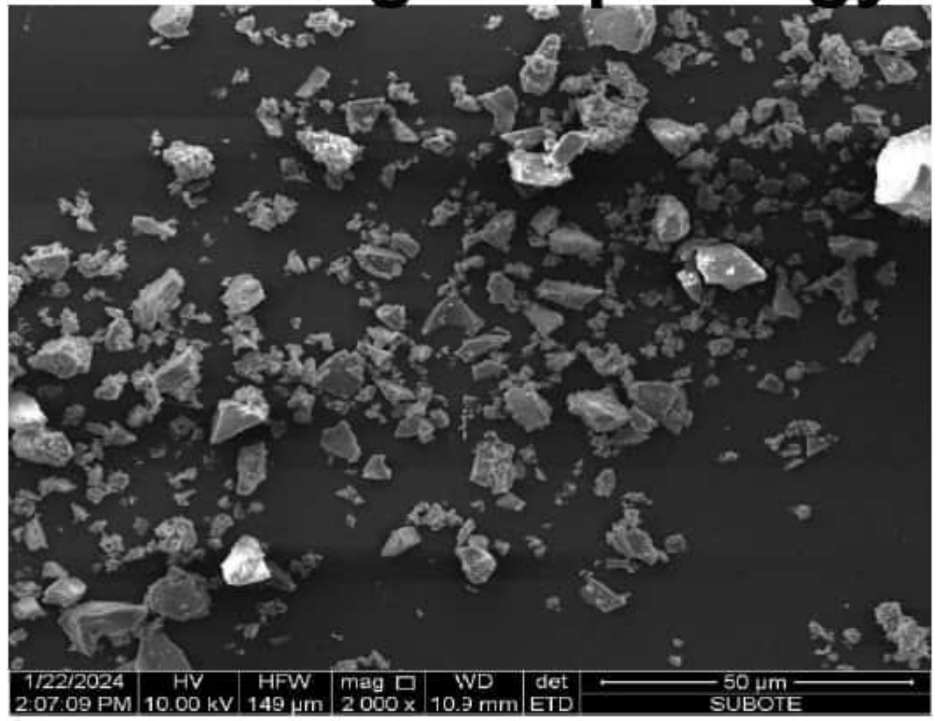
化学成分(%)	試験値	JIS A 6206の規定値
ig.loss	0.55	3.0 以下
insol	0.64	—
SiO_2	32.7	—
Al_2O_3	13.4	—
Fe_2O_3	0.5	—
CaO	41.6	—
Na_2O	0.22	-
K_2O	0.28	-
MgO	6.9	10 以下
SO_3	0.34	4.0 以下
Cl^-	0.0003	0.02 以下

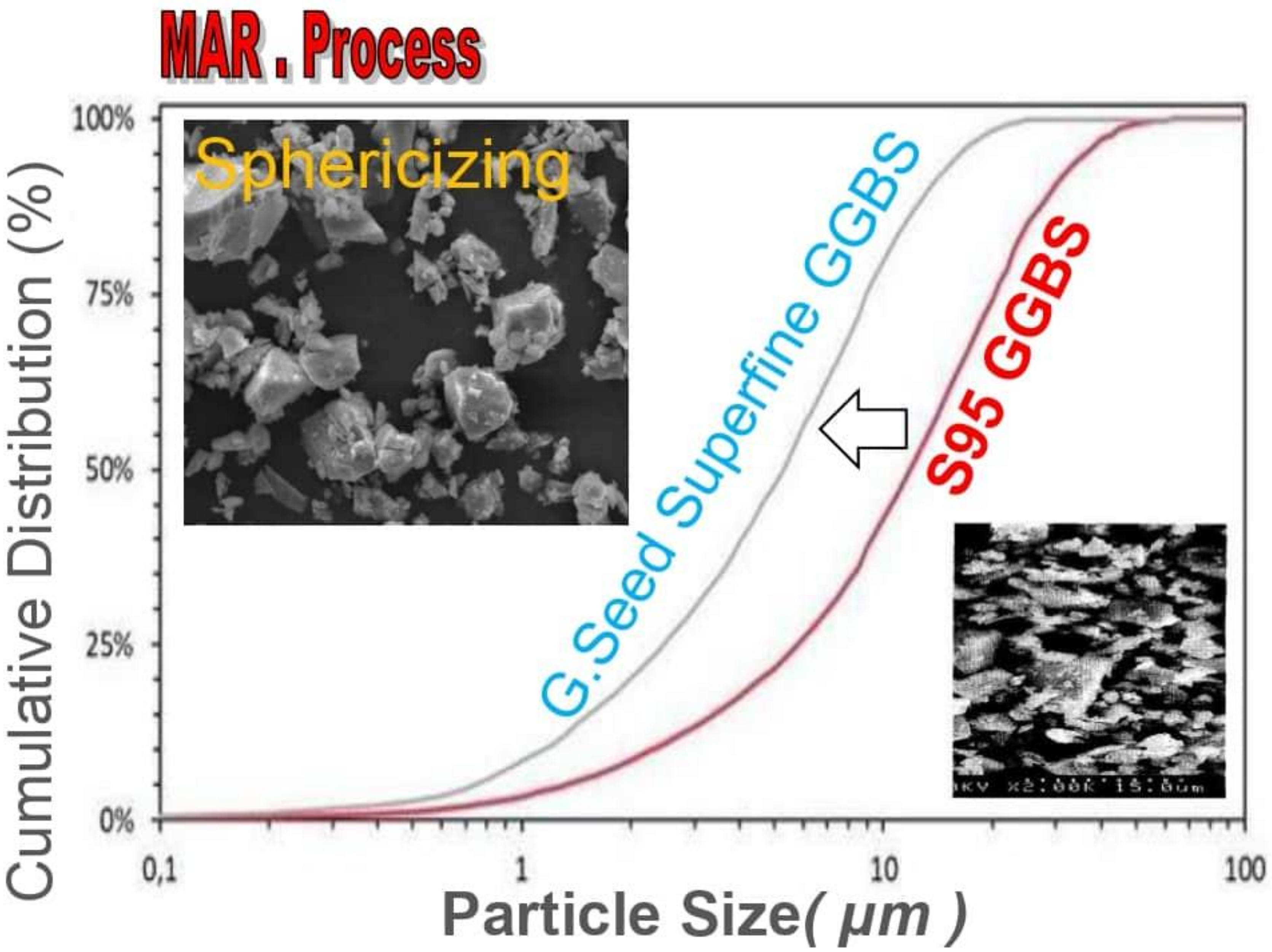
High Fineness GGBS Particle Shape

Superfine GGBS Slag



Rounding Morphology





S95 GGBS Slag

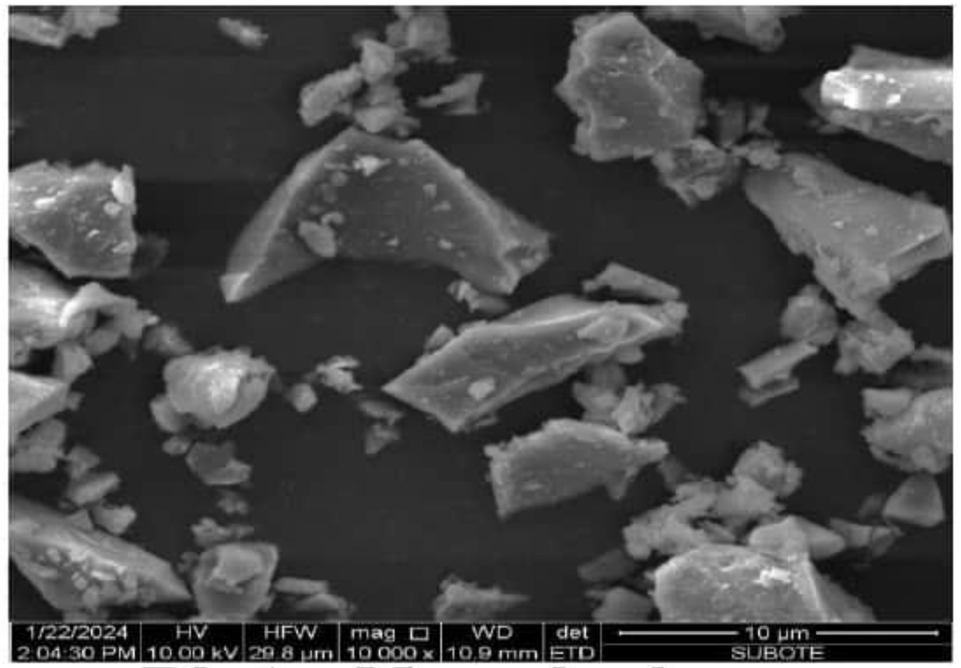
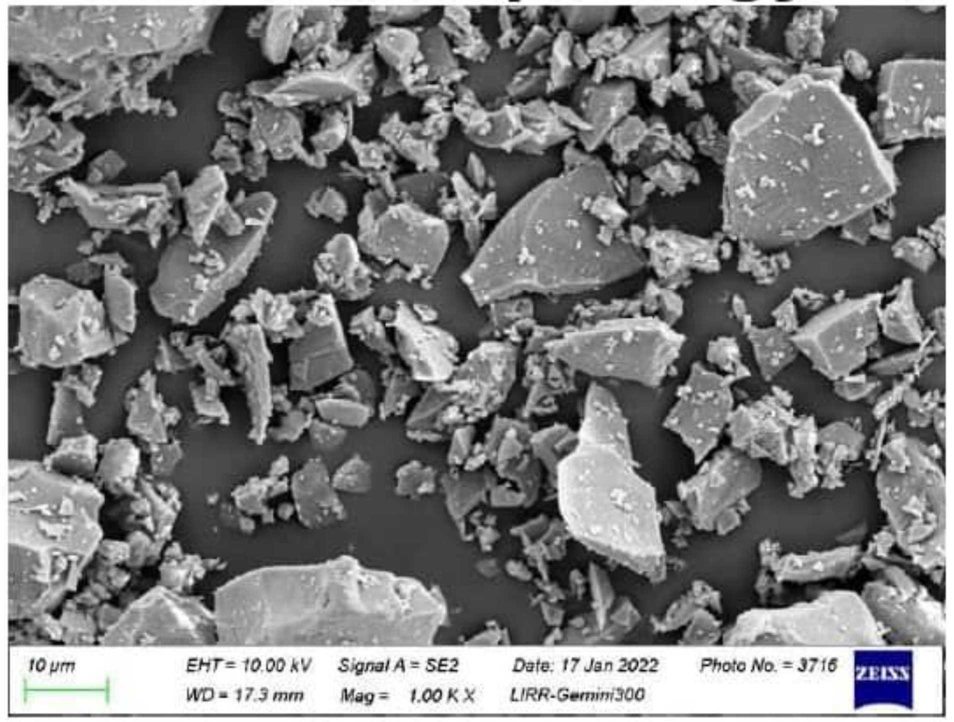


Plate Morphology



Performance of G.Seed Concrete

Superfine GGBS Fineness and Substitution Rate On Concrete Properties

	Type	S 95 GGBS 4000			Ground granulated blast-furnace slag 6000			*G.Seed Superfine GGBS 8000*		
	Blaine specific surface area (cm^2/g)	3000	≦	< 5000	5000	≦	< 7000	7000	≦	< 10000
	Substitution ratio (%)	35	50	70	35	50	70	35	50	70
Property of fresh concrete	Fluidity	○	○	○	◎	◎	◎	◎	◎	○
	Bleeding	○	○	△	◎	◎	◎	◎	◎	◎
	Setting delay effect	◎	◎	◎	◎	◎	◎	○	◎	◎
	Adiabatic temperature rise	–	–	◎	–	–	◎	–	–	◎
	Heat generation rate restraint	○	◎	◎	○	○	◎	○	○	◎
Property of strength	Initial strength	○	△	△	○	○	△	○	○	○
	28 days strength	○	○	△	○	◎	◎	◎	◎	◎
	Long-term strength	○	◎	◎	○	◎	◎	◎	◎	◎
	High strength	○	△	△	○	◎	◎	◎	◎	◎
Property of durability	Drying shrinkage	○	○	○	○	○	○	○	○	○
	Carbonation	–	–	△	–	–	△	–	–	△
	Freeze thaw	○	○	○	○	○	○	○	○	○
	Water-tightness	○	◎	◎	○	◎	◎	○	◎	◎
	Salt shield	○	◎	◎	○	◎	◎	○	◎	◎
	Seawater resistant	○	◎	◎	○	◎	◎	○	◎	◎
	Acid and sulfates resistant	○	◎	◎	○	◎	◎	○	◎	◎
	Heat resistant	○	○	○	○	○	○	○	○	○
	Alkali-silica restraint	○	◎	◎	○	◎	◎	○	◎	◎
	Abrasion resistance	○	○	○	○	○	◎	○	◎	◎

Legend:
◎ : Good property is provided in comparison with no mixture concrete.
△ : Attention is necessary for use.
○ : At the same level or a little good property is provided.
– : Property varies according to a condition.

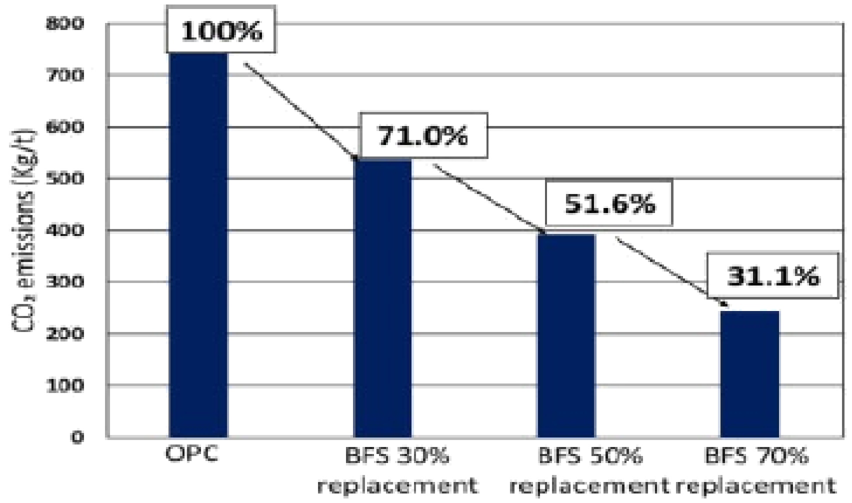
Performance of G.Seed Concrete

G.Seed Concrete			
Binder Content	**Compressive Strength (Mpa)**	**Elastic Modulus (GPa)**	
450Kg-540Kg	Grade C60-C90(Cylinder)	40-45 /	46-50
Aggregate Type :		Granite Aggregate Granite Stone Fines	Basalt Aggregate River Sand/Stone Fines
Water/Binder Ratio : 0.27 – 0.32		Workability : Flow Table Value 550 – 650 mm	

Paste Performance ⟷ **Elastic Modulus** + **Flexural Toughness** + **Compressive Strength**

Gel Morphology — **Defect Length** — **Volume Porosity**

- **Low Capital Carbon Approach**
- **Increased Service Life and Durability**
- **Reduce Steel Reinforcing And Structural Member Size**



- **And Most Importantly=> **Carbon Reduction & Cost Saving**

CONCRETE STRENGTH AND MODULUS OF ELASTICITY engineer design value

Code of Practice for Structural Use of Concrete 2013

Design values of elastic modulus for normal-weight concrete

Concrete Strength Grade	E_c (kN/mm^2)	
	For general use	For checking overall building deflection (see note 2)
C20	18.7	20.5
C25	20.5	22.2
C30	22.2	23.7
C35	23.7	25.1
C40	25.1	26.4
C45	26.4	27.7
C50	27.7	28.9
C55	28.9	30.0
C60	30.0	31.1
C65	31.1	32.2
C70	32.2	33.2
C75	33.2	34.2
C80	34.2	35.1
C85	35.1	36.0
C90	36.0	36.9
C95	36.9	37.8
C100	37.8	38.7

HPC & UHPC Concrete E-Value : China Code

超高强混凝土的强度和弹性模量（MPa）

混凝土强度等级$f_{cu,k}$		C70	C80	C90	C100	C110
标准值	轴心抗压 f_{ck}	45.0	51.0	56.0	61.0	67.0
	轴心抗拉 f_{tk}	3.0	3.1	3.3	3.5	3.8
设计值	轴心抗压 f_{cd}	31.8	36.1	40.0	43.7	48.0
	轴心抗拉 f_{td}	2.1	2.2	2.4	2.5	2.7
弹性模量 E_c ($\times 10^4$)		3.7	3.7	3.8	3.9	4.0

UHPC 立 方 体 抗 压 强 度 标 准 值 Ucuk不应小于 120MPa

强度等级	UC 120	UC 140	UC 160	UC 180	UC 200
u_{cuk} (MPa)	120	140	160	180	200
f_{Uck} (MPa)	84	98	112	126	140
f_{Ucd} (MPa)	58	68	77	87	97

UHPC 弹性模量 E_c ($\times 10^4$)

强度等级	UC 120	UC 140	UC 160	UC 180	UC 200
彈性模量	4.2	4.5	4.8	5.1	5.4

Green Active Robustness Concrete

Binder 420 - 520Kg (50% G.Seed)

E.Modulus - Product Trial Data

Done By FLEXCRETE

		Design Of 1m³ Concrete												Compressive Strength (MPa)				
Batch	Mix Volume	Cement (KG)	Flexcrete-UFGGBS (KG)	S/F (KG)	Aggregates (5-10mm) (KG)	River Sand (KG)	Z-Additives (KG)	A-Catalyst (KG)	Water (KG)	SBT RW-BP (L)	HEMI (L)	PCA-1 (L)	Remarks	12-Hour	24-Hour	7-Day	28-Day	Elastic Modulus
4th	0.04	210	210	980	770	0	0	0	134.4	1	2	7.5	Cement Reduction	Nil	18 MPa	91 MPa	99 MPa	48.5 Gpa
5th	0.04	260	234	880	770	0	26	0	166.4	1	2	6	Zeolites	Nil	28 MPa	74 MPa	79 MPa	47.0 Gpa
6th	0.04	260	260	880	770	0	0	0	166.4	1	2	6		1.5 MPa	18 MPa	88 MPa	96 MPa	46.8GPa

Customer Sample No.	Batch 4-1G
HKT Sample No.	P24C00165
Date Cast	6 Feb 2024
Age at test (days)	28
Condition of cylinder' when received	Dry
Curing and storage report	Curing in laboratory at 27+/-3°C
Type of measuring instrument	Dial Gauge
Gauge length (mm)	150.9
Diameter of cylinder (mm)	150.0
As Received density * (kg/m")	2400
Concrete cube strength (MPa)	102.2
Maximum applied stress (MPa)	27.2
Compressive strength of cylinder (MPa)	93.34
Static modulus of elasticity (MPa)	
Static modulus of elasticity (GPa)	

Customer Sample No.	Batch 5-1G
HKT Sample No.	P24C00167
Date Cast	6 Feb 2024
Age at test (days)	28
Condition of cylinder' when received	Dry
Curing and storage report	Curing in laboratory at 27+/-3°C
Type of measuring instrument	Dial Gauge
Gauge length (mm)	150.9
Diameter of cylinder (mm)	150.0
As Received density * (kg/m")	2400
Concrete cube strength (MPa)	80.6
Maximum applied stress (MPa)	20.98
Compressive strength of cylinder (MPa)	76.77
Static modulus of elasticity (MPa)	43,500
Static modulus of elasticity (GPa)	47.0

Customer Sample No.	Batch 6-1J
HKT Sample No.	P24C00170
Date Cast	6 Feb 2024
Age at test (days)	28
Condition of cylinder' when received	Dry
Curing and storage report	Curing in laboratory at 27+/-3°C
Type of measuring instrument	Dial Gauge
Gauge length (mm)	150.8
Diameter of cylinder (mm)	150.0
As Received density * (kg/m")	2400
Concrete cube strength (MPa)	93.4
Maximum applied stress (MPa)	24.9
Compressive strength of cylinder (MPa)	97.96
Static modulus of elasticity (MPa)	46,800
Static modulus of elasticity (GPa)	46.8

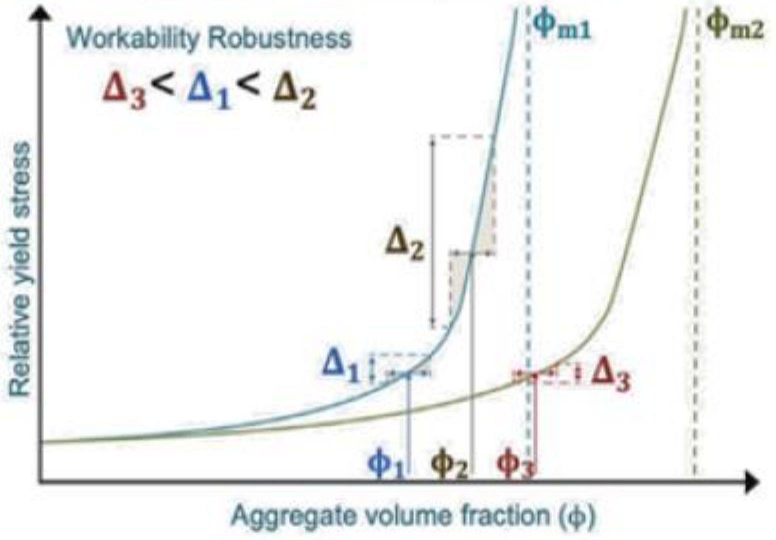
Performance of G.Seed Concrete

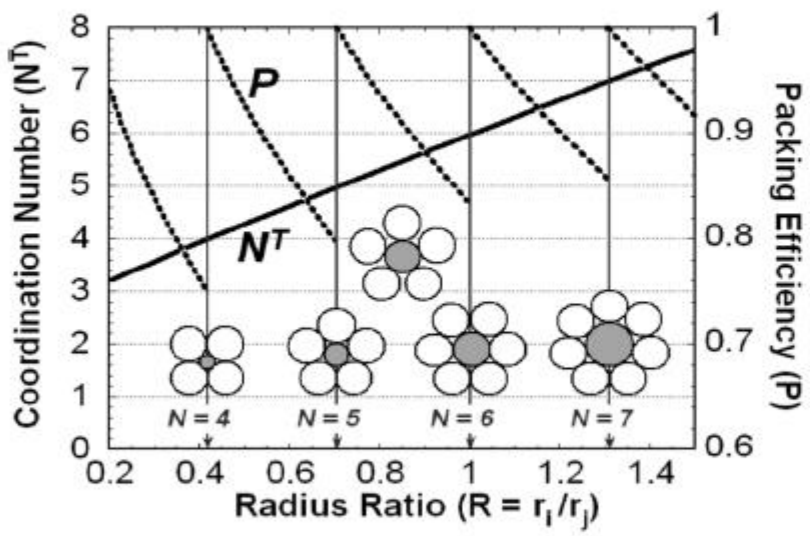
Test Done By Nami

Green Active Robustness Concrete

Binder : 520 KG/M3 (50% G.Seed Superfine GGBS)
(Fine Aggregate : Granite Stone Fines) (Coarse Aggregate : Granite-10mm & 20mm)

No.	w/b	S/A	Paste volume	Bulk Density	Flow table value	Compressive Strength	Elastic Modulus
				Kg/m3	mm	MPa	GPa
Batch 4-2	0.307	0.53	0.35	2370	300	55.7	**42.5**
M10-0.34	0.320	0.50	0.34	2400	400	66.1	**42.2**
M10-0.34-1	0.306	0.50	0.34	2400	550	99.0(56d)	**45.8**
M10-0.34-2	0.306	0.50	0.34	2405	530	**98.0**	**44.8**





High Grade – No Silica Fume Mix

14 Days Test Result

Plastic Density (Kg/M³)	2390	
Yield	0.999	
Initial (Slump/Stump Flow)	225	
Cube Age (Day)	Strength	Test Date
3	84.5, 84.7	18/03/2024
7	103.2, 105.6	22/03/2024
28		12/04/2024

Lab Trial No.	LTM5988				
Date Cast	15/03/2024				
Concrete Mix	80D/20GGBS+CSF				
Slump/Flow	200				
Volume (M³)	Design (1m3)	Finial (1m3)	0.045	+/- Adjust	After Adjust (+/-)
Cement (Kg)	273	273	12.29		
PFA (Kg)	0	0	0.00		
GGBS (Kg)	274	274	12.33		
Silica Fume (Kg)	0	0	0.00		
20mm (Kg)	565	565	25.43	0.03	25.45
10mm (Kg)	435	435	19.58	0.18	19.75
CRF (Kg)	410	410	18.45	0.37	18.82
R/S (Kg)	270	270	12.15	0.30	12.45
Water (Kg)	150	150	6.75	0.87	5.88
RW-BP	1.85	1.85	83ml	RW-BP	
PCA-1	6.56	6.33	285ml	PCA-1	
HEMI	2.50	2.50	113ml	HEMI	
-	0.00	0.00	0ml	-	
-	0.00	0.00	0ml	-	
-	0.00	0.00	0g	-	
-	0.00	0.00	0g	-	
Total Weight (Kg/M³)	2388	2388			
A/C	3.07	3.07			
W/C	0.27	0.27			

(b) Determination of Loading	Stress	Loading Force*
Upper Loading Stress ($\sigma_a = f_c / 3$)	31.8 (MPa)	561.2 (kN)
Basic Stress (σ_b = 0.5MPa)	0.5 (MPa)	8.8 (kN)
Cross-sectional area of Cylinder, (mm²)	17645	

*Loading force shall be calculated by multiplying the stress by the cross-sectional area of cylinder.

(b) Determination of Strain Reading	1st Cycle	2nd Cycle	3rd Cycle	Average
Strain under the Upper Loading Stress (ε_a)	[illegible]	[illegible]	[illegible]	[illegible]
Strain under the Basic Stress (ε_b)	[illegible]	[illegible]	[illegible]	[illegible]

The Static Modulus of Elasticity in Compression [$E_c = (\sigma a - \sigma_b)/(\varepsilon_a - \varepsilon_b)$ *1000, GPa]	**52 GPa** 52.0
Compressive Strength of Test Specimen (MPa)	**116 MPa** 116.

Compression Testing Machine, Strain Measuring Apparatus, Data Logger (TC-32K)

Tested By 測試人：

Checked By 查核人： Date of Issue 簽發日期：

(b) Determination of Loading	Stress	Loading Force*
Upper Loading Stress ($\sigma_a = f_c / 3$)	30.2 (MPa)	538.4 (kN)
Basic Stress (σ_b = 0.5MPa)	0.5 (MPa)	8.8 (kN)
Cross-sectional area of Cylinder, (mm²)	17694.5	

*Loading force shall be calculated by multiplying the stress by the cross-sectional area of cylinder.

(b) Determination of Strain Reading	1st Cycle	2nd Cycle	3rd Cycle	Average
Strain under the Upper Loading Stress (ε_a)	[illegible]	[illegible]	[illegible]	[illegible]
Strain under the Basic Stress (ε_b)	[illegible]			

The Static Modulus of Elasticity in Compression [$E_c = (\sigma a - \sigma_b)/(\varepsilon_a - \varepsilon_b)$ *1000, GPa]	**50.5 GPa** 50.5
Compressive Strength of Test Specimen (MPa)	**107 MPa** 106.8

Compression Testing Machine, Strain Measuring Apparatus, Data Logger (TC-32K)

Tested By 測試人：

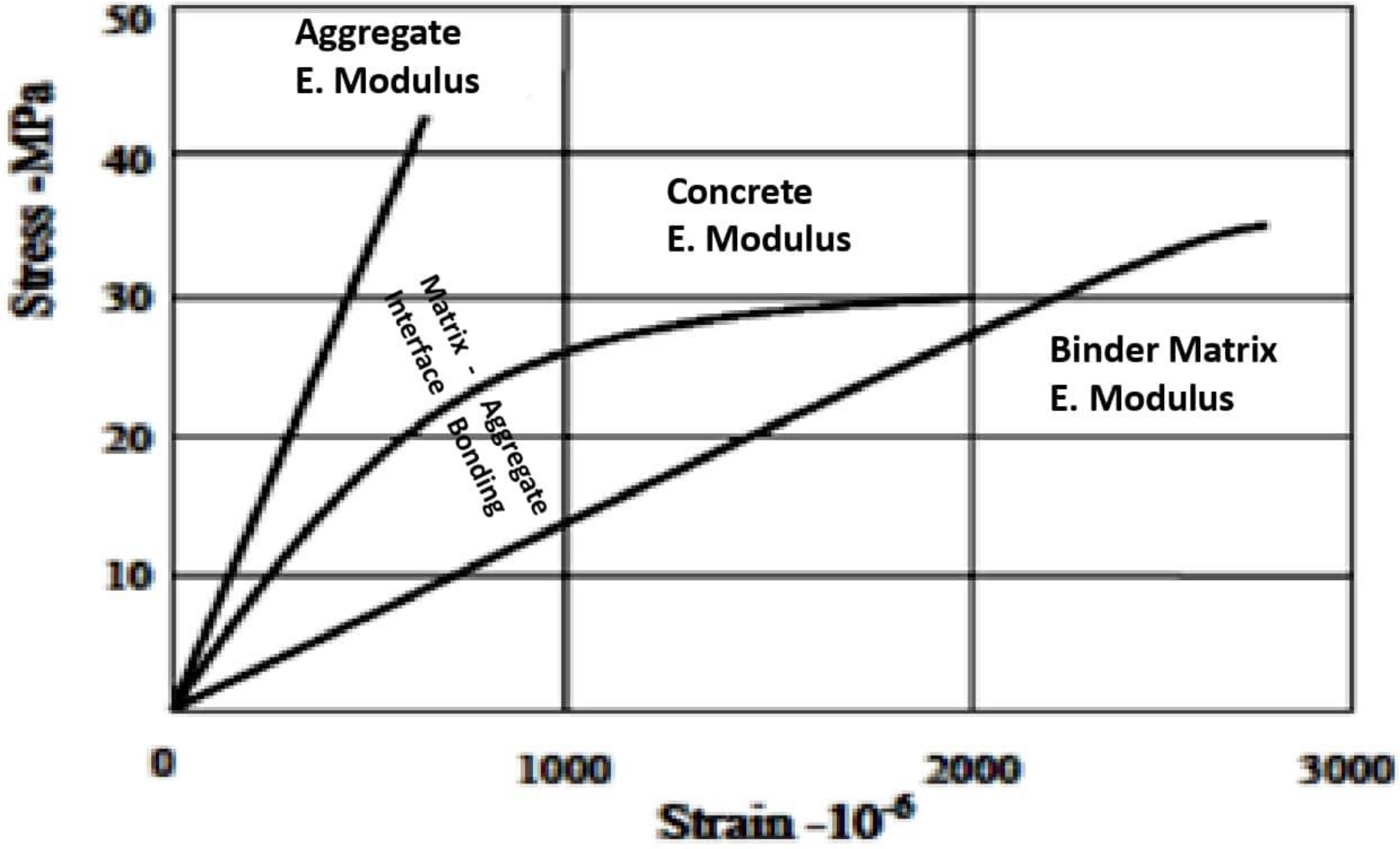
Checked By 查核人： Date of Issue 簽發日期：

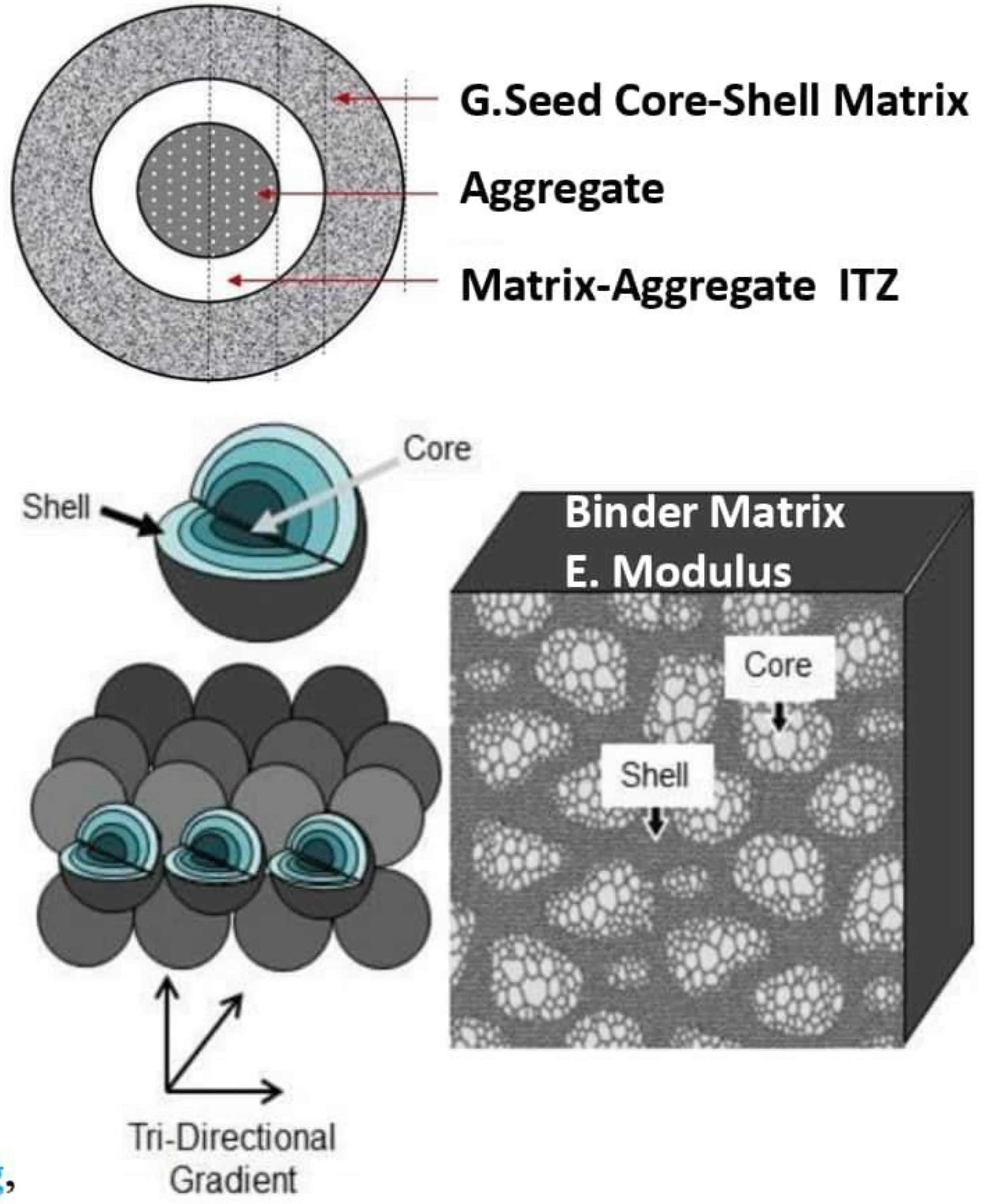
Typical High Strength Concrete Mix

	NAMI's High Strength Concrete		
	C80	C90	C100
Compressive Strength	28 Days		
	98.4MPa	111.8MPa	119. 4MPa
Elastic modulus	37.9GPa	39.7GPa	40.7GPa

Tailoring Concrete Modulus Of Elasticity

The moduli of most materials depend on two factors: bond stiffness, and the density of bonds per unit volume.





Diamond has a very high modulus because the carbon atom is small (giving a high bond density) and its atoms are linked by very strong springs (S ¼ 200 N/m).

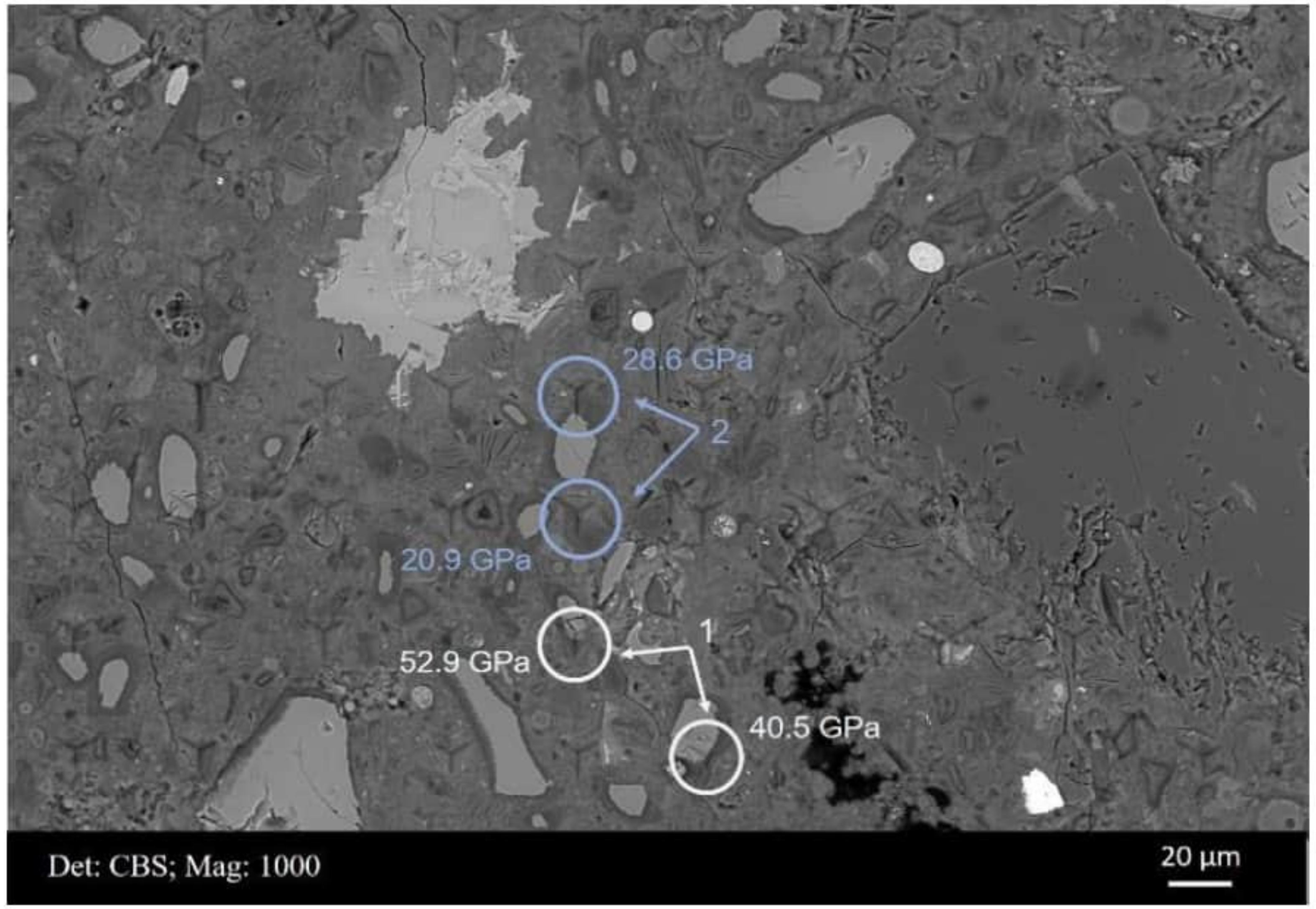
Metals have high moduli because close-packing gives a high bond density and the bonds are strong, though not as strong as those of diamond.

GGBS Grain Size And Hydration Characteristics

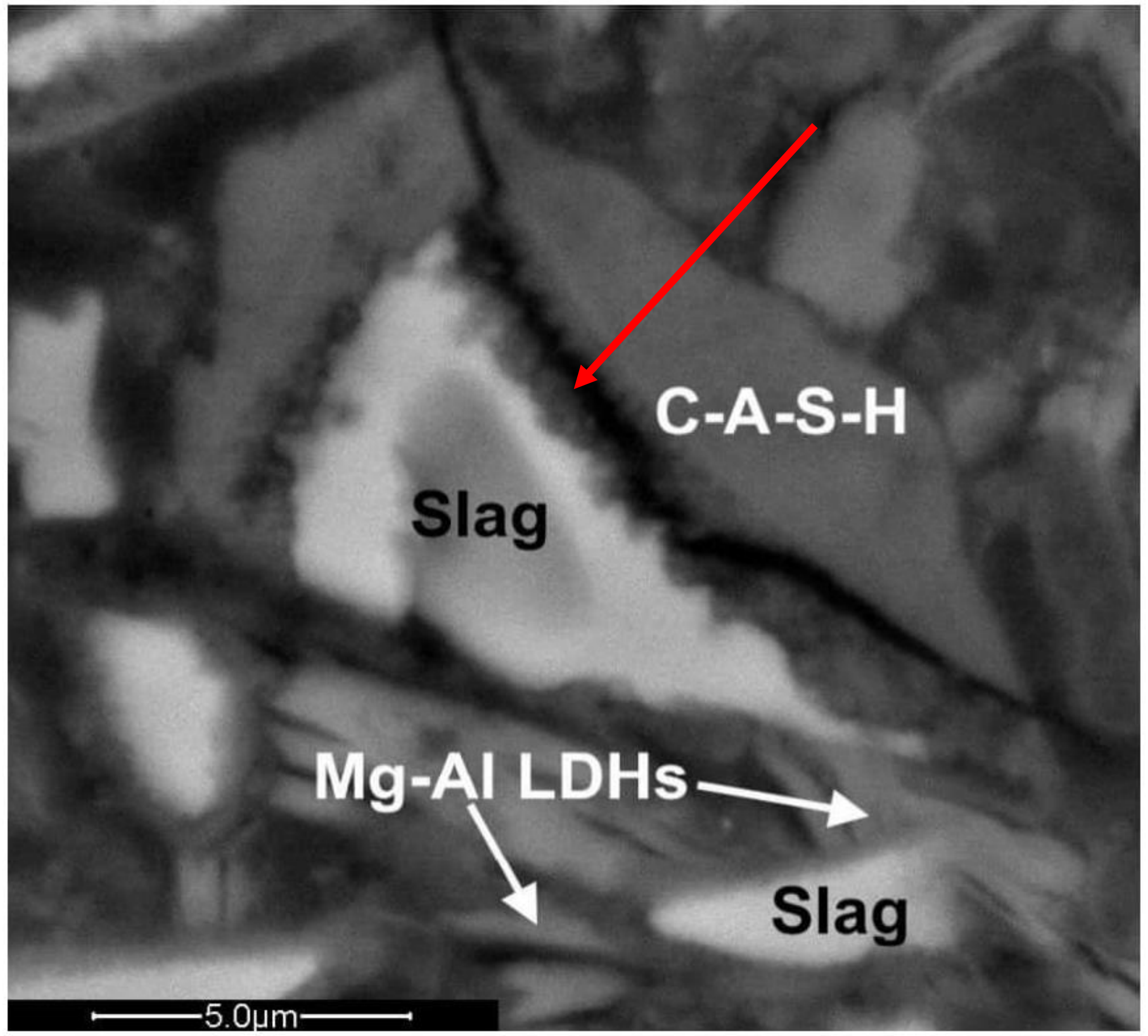
Reference

MicroMechanical Properties of Slag Rim Formed in Cement–Slag System

Slag rim mainly consists of secondary precipitations such as C–S–H gel phase and hydrotalcite- like phase, which originate from the hydration of slag.
It was found that, compared to the C–S–H gel phase, slag rim showed about a 15 GPa higher modulus of elasticity.

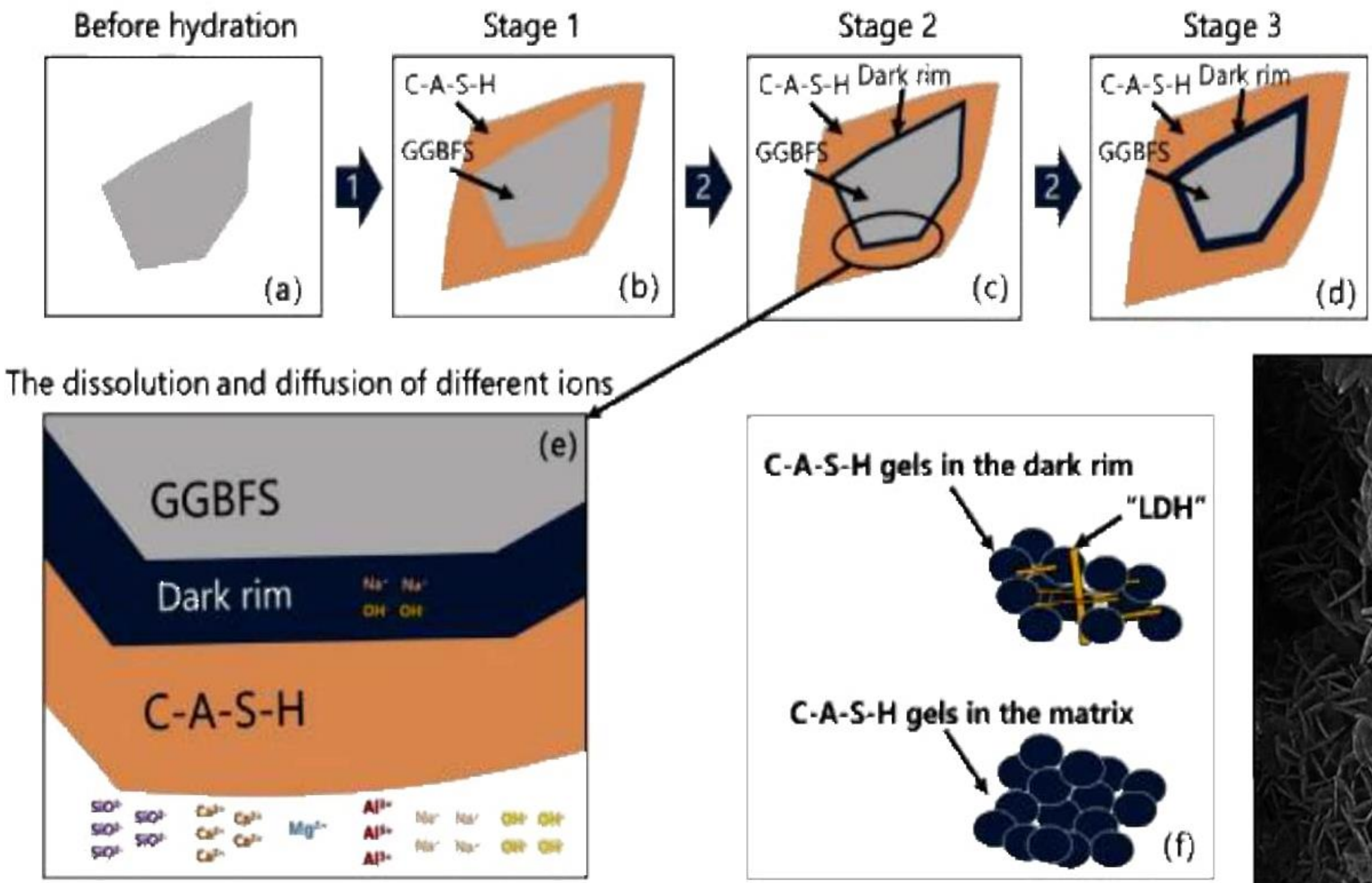


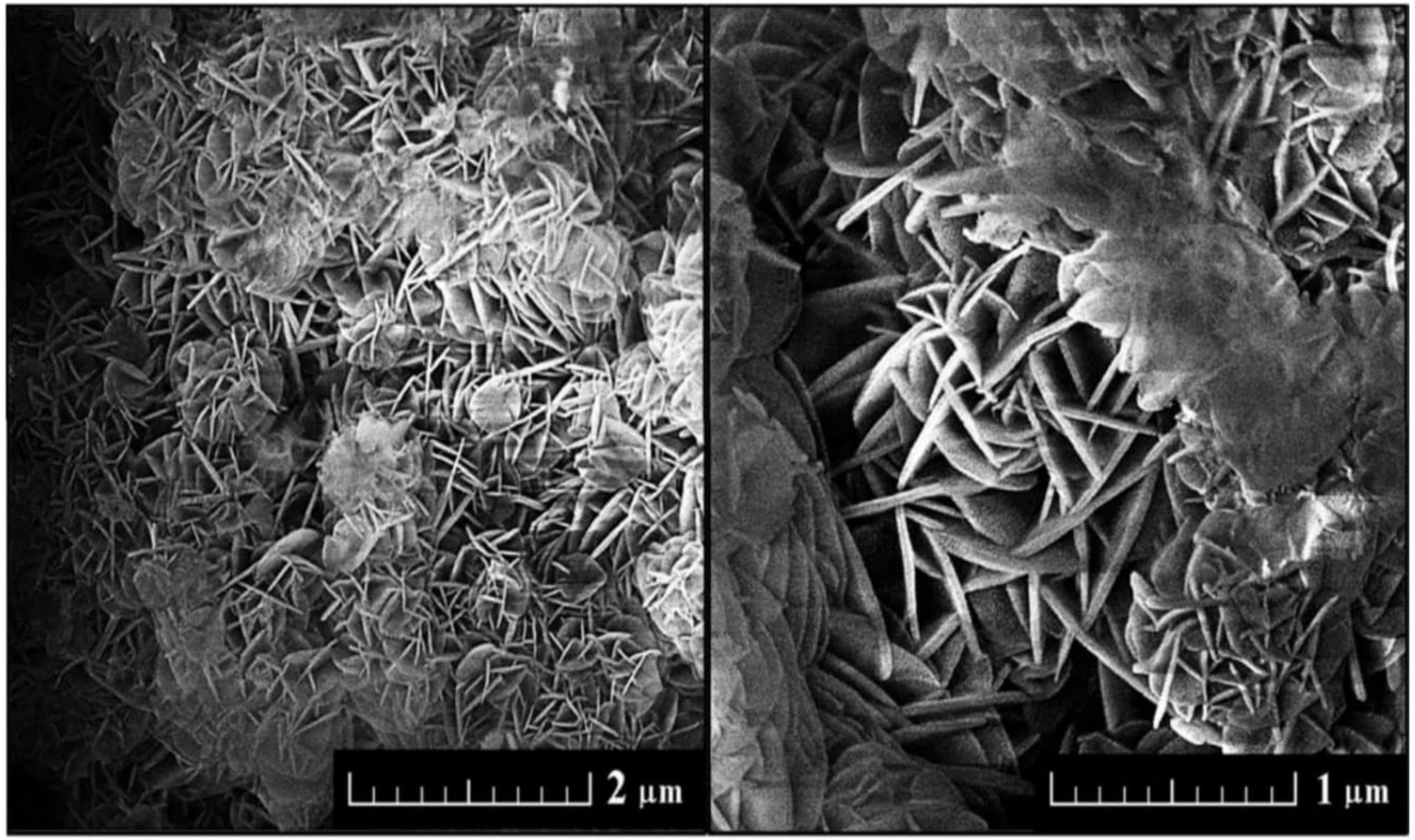
The hydrotalcite-like phase, as the main precipitation of pozzolanic reaction between slag and portlandite, is closely intermixed with the C–S–H gel phase, forming the so-called 'inner' products of slag within the original slag region. The rims around unreacted slag particles become thicker, and totally hydrated slag grains at a size of >10 µm are also frequently observed.



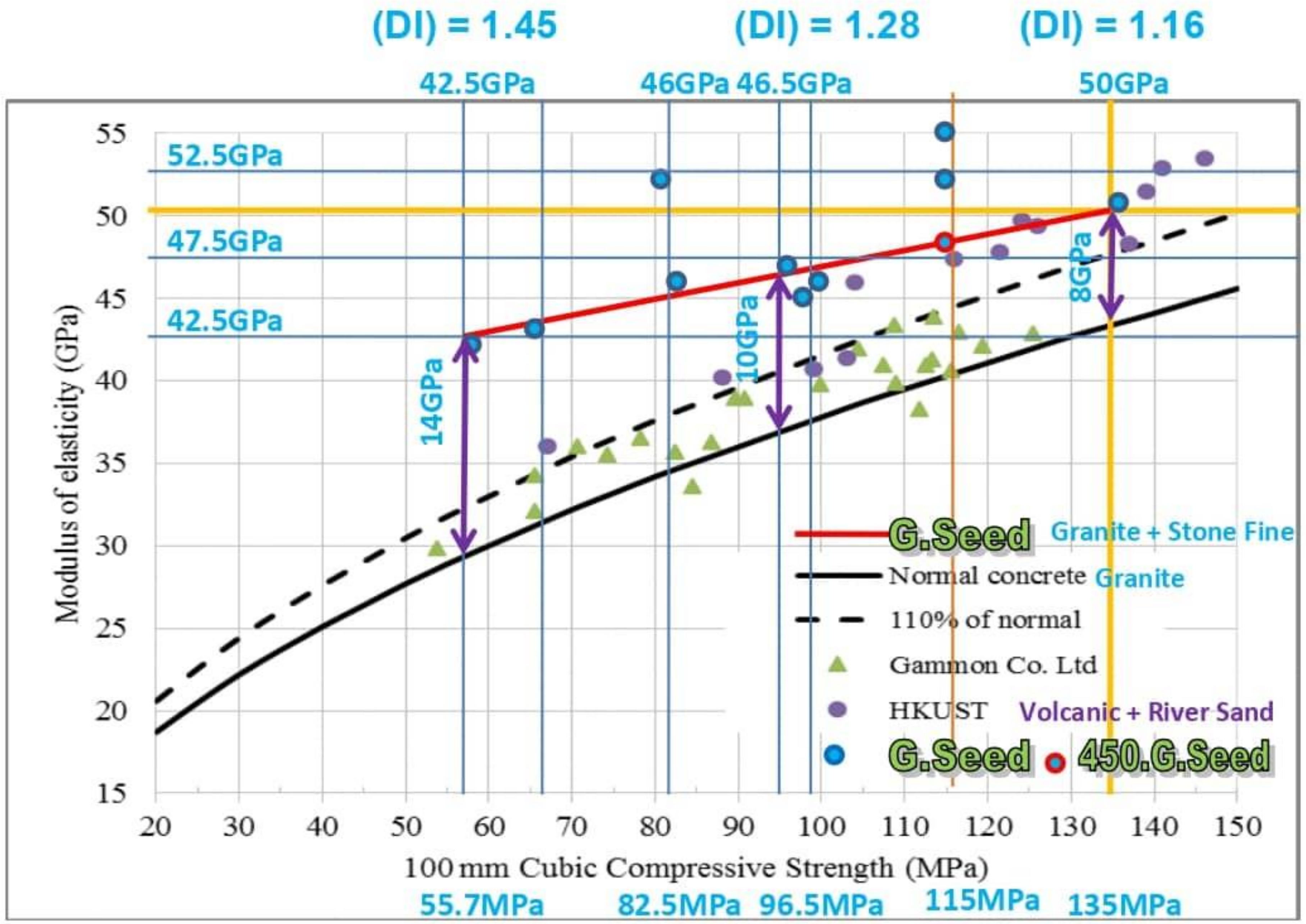
Layered Double Hydroxides - LDH

Reference





Green Active Robustness Concrete



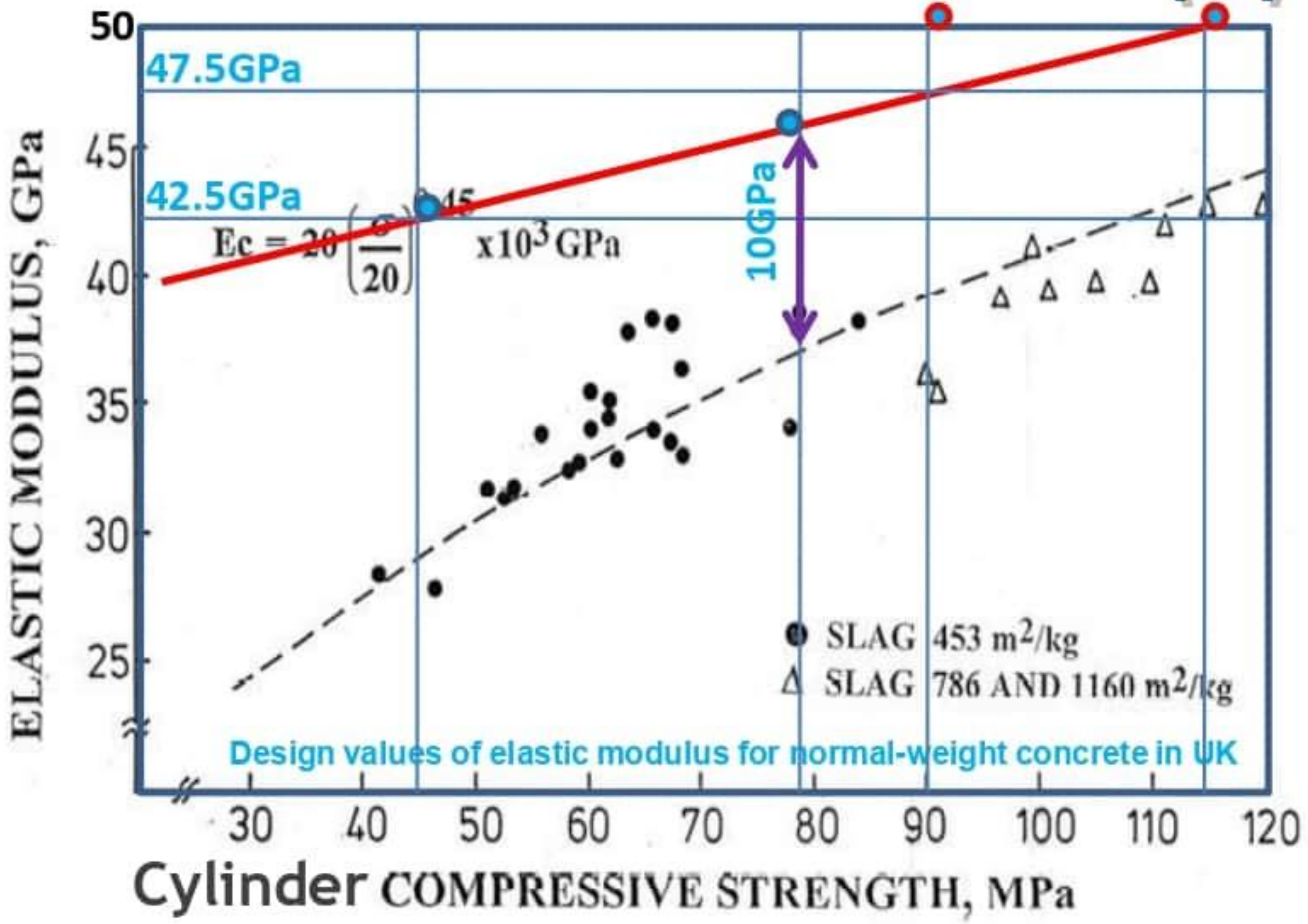
Design values of elastic modulus for normal-weight concrete in Hong Kong

$E_c = 3.46\sqrt{f_{cu}} + 3.21$ where:

E_c is the short-term static modulus of elasticity,

f_{cu} is the cube compressive strength in N/mm^2.

G.Seed E.Modulus Increment (EI)



450 - Ultra Green Concrete < Grade 80 >

$E_c = 4.45\sqrt{f_{cu}} + 3.13$ where:

E_c is the short-term static modulus of elasticity,

f_{cu} is the cube compressive strength in N/mm^2.

Deformation Index (DI) = 4.45/3.46 = 1.28

Thank You