MASTER® BUILDERS SOLUTIONS

Ultra High Strength Concrete (UHSC) for Concrete Industry

Jakarta, 2021

A brand of MBCC GROUP

MBCC Group at a Glance

- The MBCC Group is one of the leading suppliers of construction chemicals and solutions worldwide
- We offer innovative and sustainable products and solutions for the construction industry across different sectors such as buildings, structures and underground construction, new construction, as well as renovation
- Our strong main brands Master Builders Solutions, PCI, Thermotek, Wolman, Colorbiotics and Watson Bowman Acme, are well established in the marketplace
- Our success was and will always be based on the technical skills and knowledge of our people and experts, combined with the quality and performance of our products and solutions
- With our innovations we address sustainability challenges in the industry

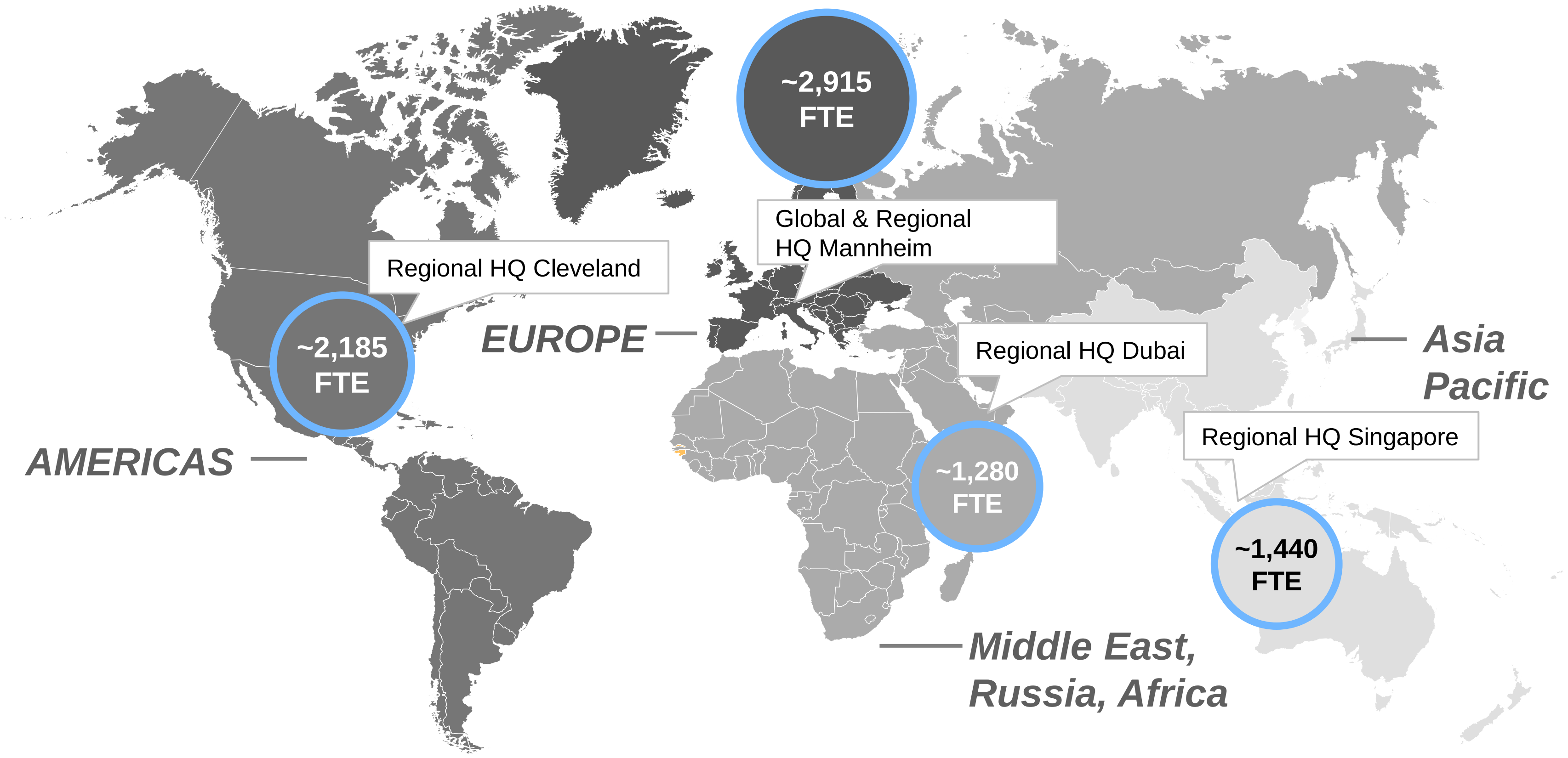
We build sustainable performance.

Follow us on social media:

Visit our website:
https://www.mbcc-group.com/

MBCC Group is a Leading Player in the Construction Chemicals Industry With a Truly Global Footprint

Strong regional presence in ~ 70 countries, around 7,500 employees promoting customer focus, efficient structures, and fast-decision making



Our strong brands

We are Looking Back at 110 Years of Heritage – Now is the Time to Build the Future of MBCC Group

MBCC Group – Our journey

Starting our venture | **Becoming one of the leading construction chemicals suppliers** | **Positioning & shaping our business for sustainable growth** | **Striving together as MBCC Group**

1909
Founding of Master Builders Inc.

2001
Merger of Degussa-Hüls and SKW Trostberg

2006
Acquisition by BASF

We create chemistry

2010-2013
Repositioning & reshaping

2013
Launch of Master Builders Solutions

2015
Advancement of our strategic growth path through acquisitions

PROTEGE LO QUE MÁS QUIERES

make it!

2020
Starting point of MBCC Group

Lone Star has Profound Understanding of the Construction Industry Through Previous Investments With Focus on Europe

Lone Star's portfolio companies in the construction industry

Portfolio companies

Adjacent industries (examples)

Construction industry

balta	Manufacturer of soft flooring	Belgium	2017
esmalglass·itaca grupo	Producer of pigments, glazes, frits, inks and ceramic additives[1)]	Spain	2017
STARK GROUP	B2B retailer & distributor of building materials	Denmark	2018
raab karcher	B2B retailer & distributor of building materials	Germany	2019
Xella	Solution provider of building materials and related industries	Germany	2017
URSA	Producer of glass wool XPS insulation	Spain	2017
EDILIANS	Manufacturer of clay roof tiles	France	2018
MBCC GROUP		Germany	2020

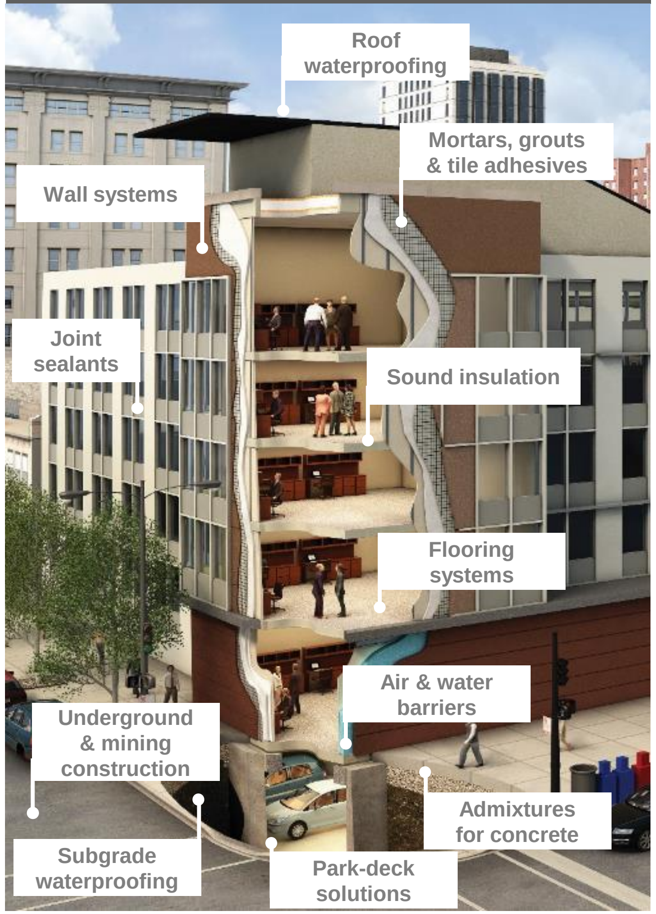
MBCC Group is a perfect fit

- Lone Star as one of world's leading private equity investors in construction materials and related industries.
- Already strongly engaged in European building materials sector with combined sales > EUR 5 bn.
- MBCC Group complementing previous acquisitions, together forming a strong network of leading players in the construction industry.
- MBCC Group will be a standalone company within the Lone Star portfolio.

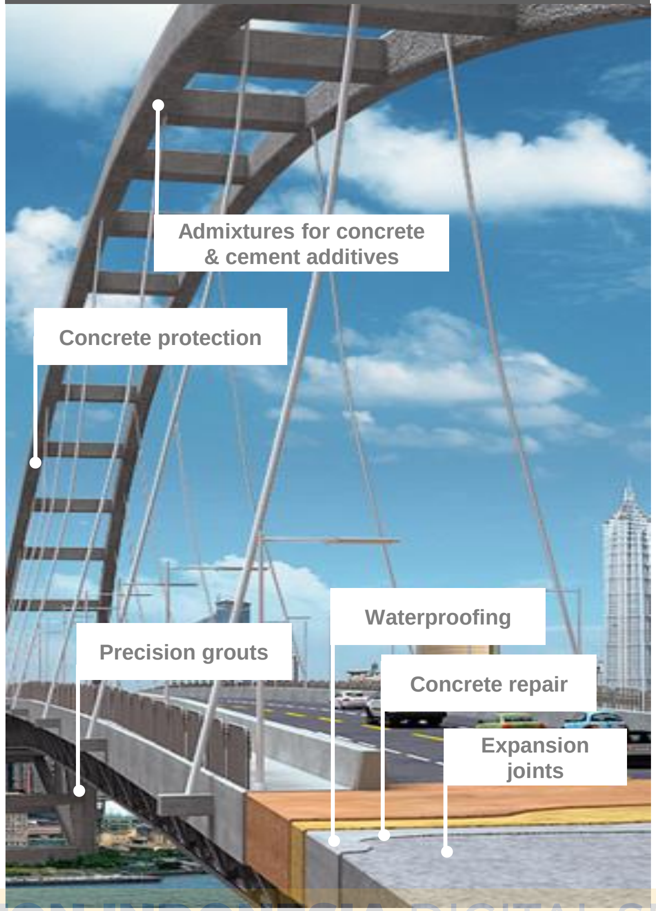
1) Announced acquisition of Tile Coatings business of Ferro Corporation in December 2019

MBCC Group Offers a Variety of Solutions for Different Applications, Meeting Diverse Needs of the Construction Industry

Commercial/Industrial



Infrastructure



Residential

MBCC Group Operates in Three Business Units – Admixture Systems, Construction Systems and Specialties

MBCC Group – Business segmentation

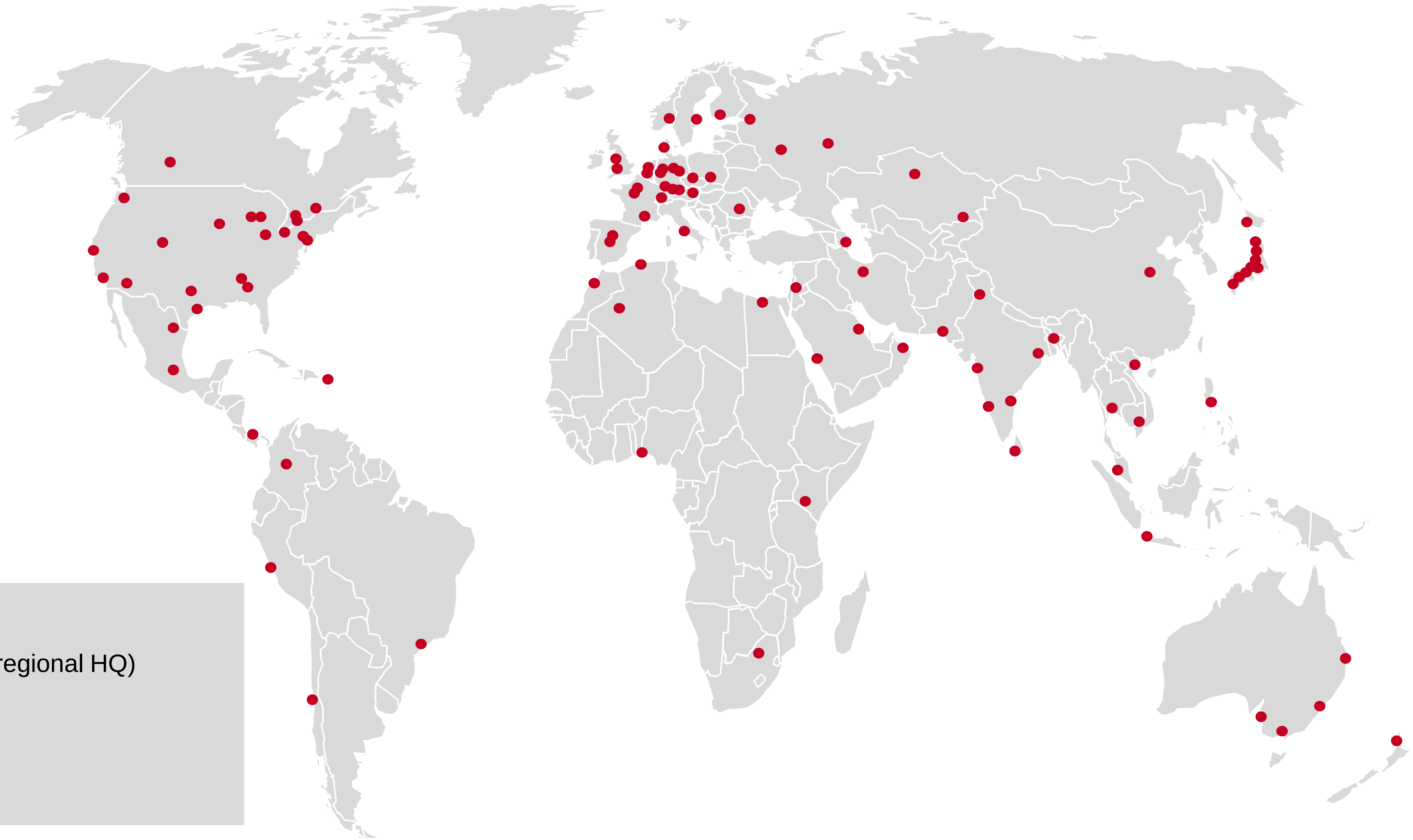
Company	**MBCC Group** (100% owned by Lone Star) MBCC GROUP							
Business units	**Admixture Systems (46%)**			**Construction Systems (49%)**			**Specialties (5%)**	
Segments	**Concrete Admixtures**	**Underground Construction**	**Others**	**Construction Solutions**	**Performance Flooring**	**Tiling & Floor Laying Systems**	**Wood Protection**	**Mulch Colorization**
								
Main brands	Master Builders Solutions			Master Builders Solutions; Watson Bowman Acme; Thermotek		PCI Für Bau-Profis	Wolman	Colorbiotics

Experience Gained from Construction Projects Worldwide

MBCC Group Sites Worldwide

R&D Sites

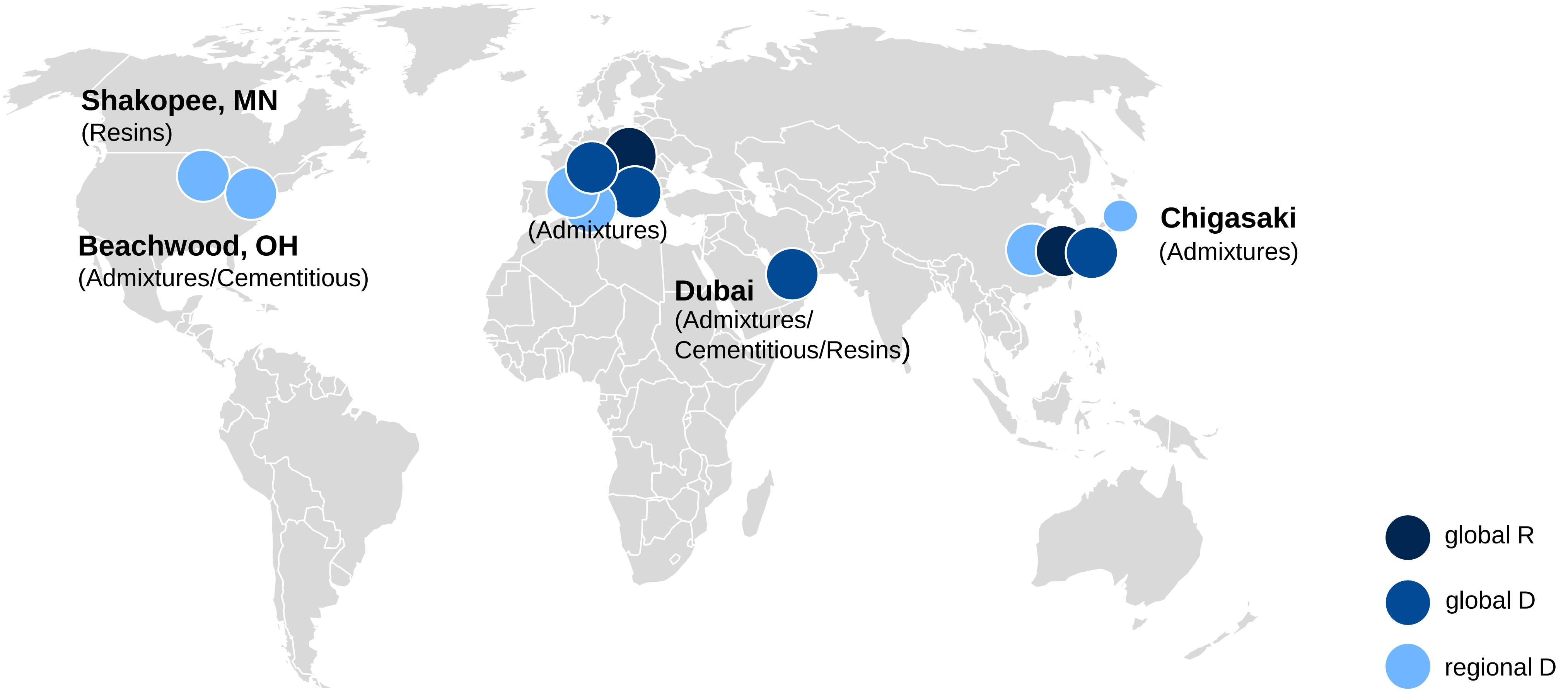
- Trostberg, Germany
- Sinzheim, Germany
- Augsburg, Germany
- Cleveland, US
- Shakopee, US
- Shanghai, China
- Chigasaki, Japan
- Treviso, Italy
- Dubai, UAE



Headquarters

- Mannheim, Germany (global & regional HQ)
- Cleveland, US (regional HQ)
- Singapore (regional HQ)
- Dubai, UAE (regional HQ)

Global and Regional R&D Centers



- Main development hubs shown. Local extensions are:
  Redditch, UK (Flooring), Oldenburg (Resins)
- Technical Centers for technical support and local formula adaptation not shown.
  Development Centers for regional segments (e.g. ECS, Wood Protection) also not shown.

Our Admixtures Pushed the Border of “Impossible”

- Master Builders Solutions is the chosen partner for the most challenging projects. For example, all skyscrapers in the world above 500m height are built with premium range of MBCC Group admixtures

Self Consolidating Concrete
Pull marketing for MasterGlenium through Kumagai.

Green Sense Concrete
Specified by the Port Authority of New York.

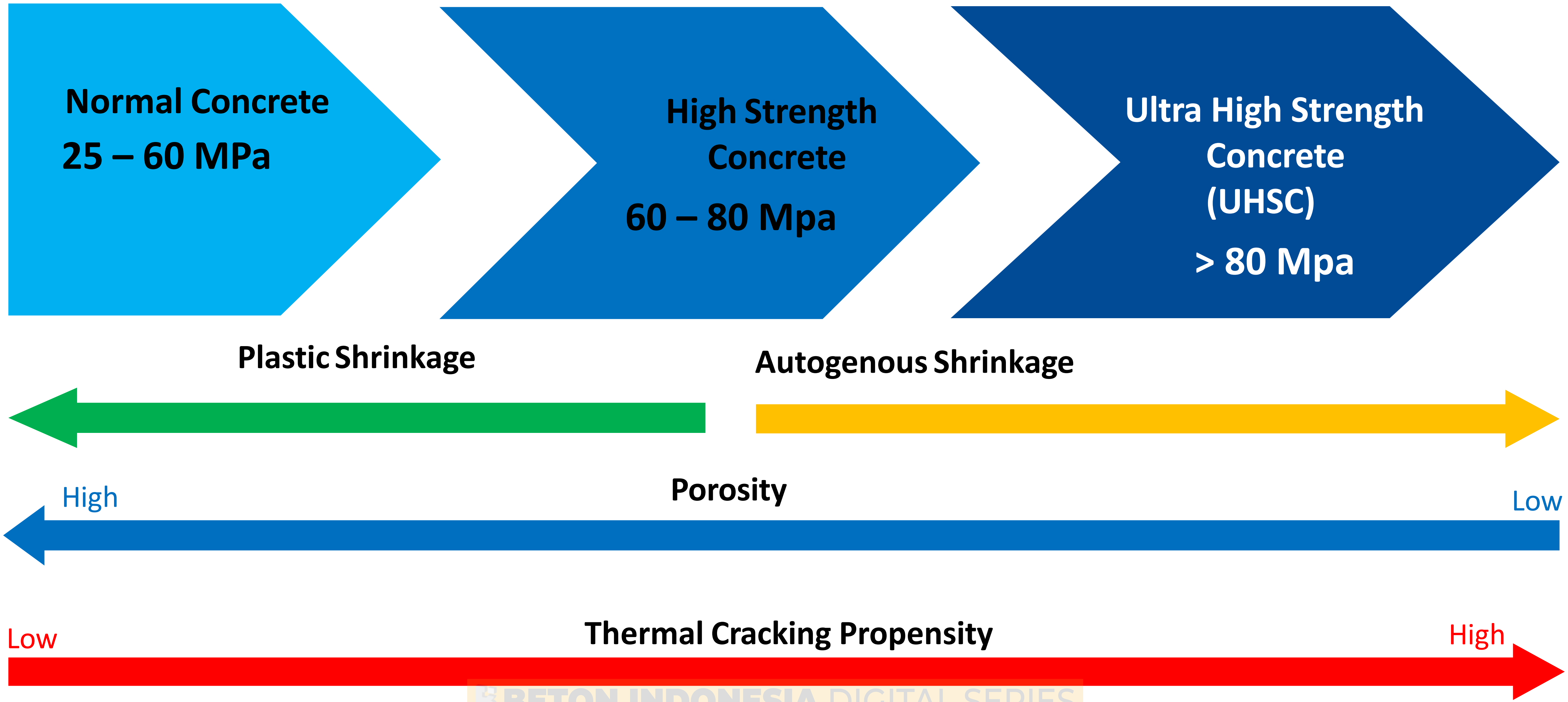
MasterGlenium
Applied by Saudi Bin Laden construction group.

Smart Dynamic Concrete
Pull marketing through Shanghai Construction Group.

MasterGlenium
Applied in a Skidmore, Owings & Merrill project.

MasterGlenium
Applied by Saudi Bin Laden construction group. Skidmore, Owings & Merrill project.

Ultra High Strength Concrete (UHSC) – What?



HPC vs High Strength Concrete

- A High Strength Concrete (HSC) is always a high-performance concrete, but a High Performance Concrete (HPC) is not always a high-strength concrete.
- Spec of HSC generally results in a true performance specification in which the performance is specified for the intended application, and the performance can be measured using a well-accepted standard test procedure. The same is not always true for a concrete whose primary requirement is durability.

Compressive Strength (MPa)	50	75	100	125	150
High performance class	I	II	III	IV	V

(Source: Ryan Megenedy, Technovitions, on High Performance Concrete)

A HPC is something more than is achieved on a routine basis and involves a specification that often requires the concrete to meet several criteria

Ultra High Strength Concrete (UHSC) – Why ?

Longer Life of Structures

Life Cycle Cost Reduction

Taller Buildings

Reduction of Column Space

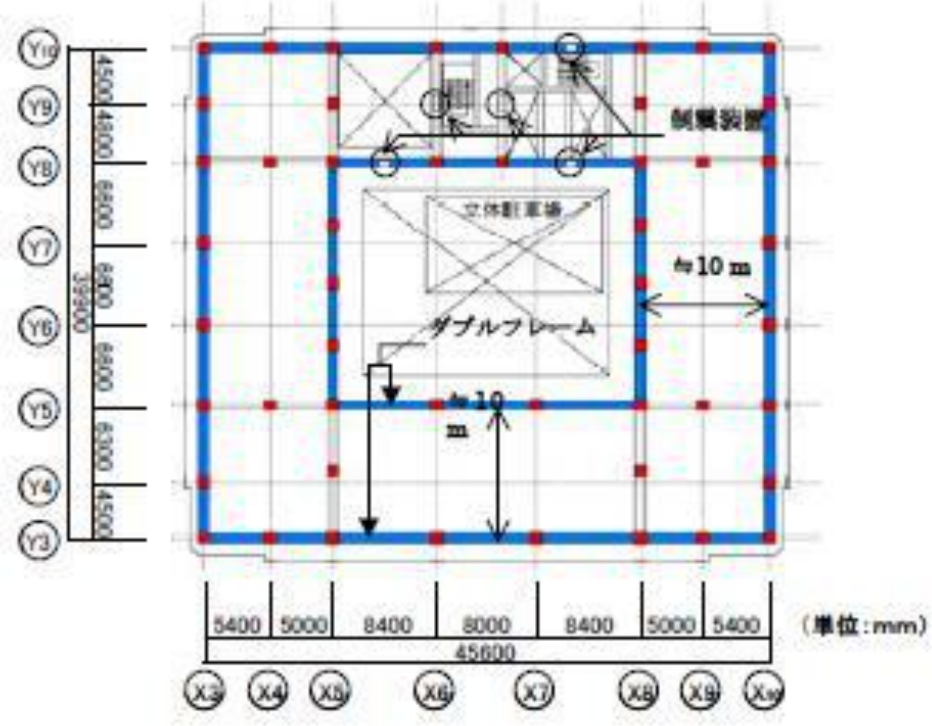
Durability against Earthquakes

...strengths > 80 Mpa
become necessary....

UHSC Application
Trend of Architectural Design

- **1. To get wider floor space by downsizing columns**
- **2. To get no-column living space for flexible interior design**

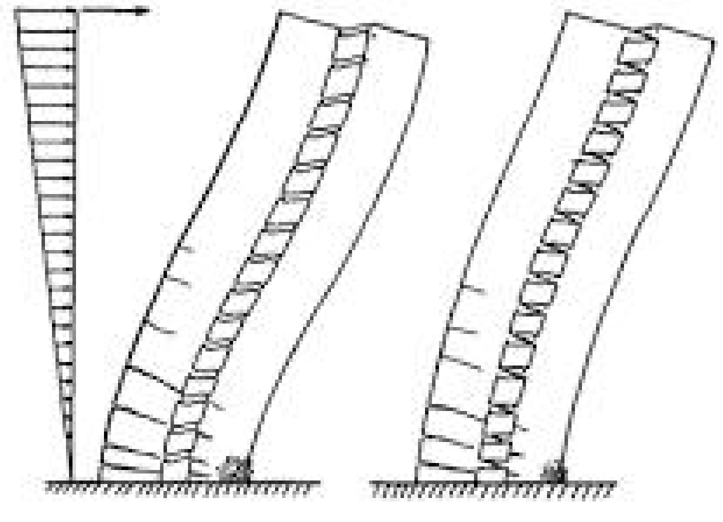
10m span was possible at **KOSUGI TOWER** using 150Mpa concrete. Colum distribution plan as follows…



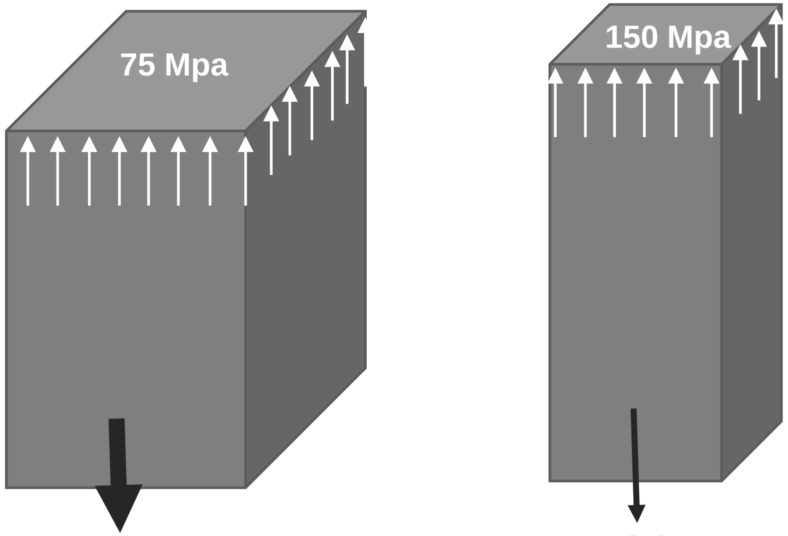
Application of UHSC
More Earthquake Resistance

- ❑ **Higher strength for smaller dimension**
- ❑ **Smaller dimension will make it lighter**
- ❑ **Lighter but stronger will make it more earthquake resistant**

Using 150Mpa concrete can give smaller dimension than 75 Mpa concrete

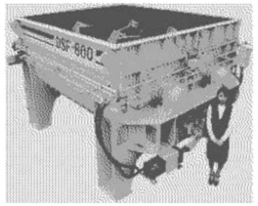


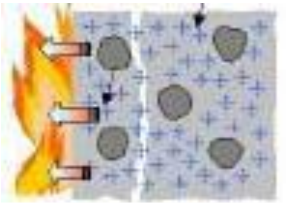
a) b)



Technical Challenges

- Dispersing ability of cement very poor at low water cement ratios
- The viscosity of concrete is very high, especially if polymer fibers are applied.
- Thixotropy of concrete tends to be high.
- Slump and flow of concrete eventually increase over time, bearing the risk of segregation.
- Mixing time tends to be exceptionally long.
- Strength management (unit water, curing condition)
- Cracking potential with high thermal gradients
- Fire resistance





Raw Material

Cement : Ordinary Port-land, Low heat, Silica fume premixed

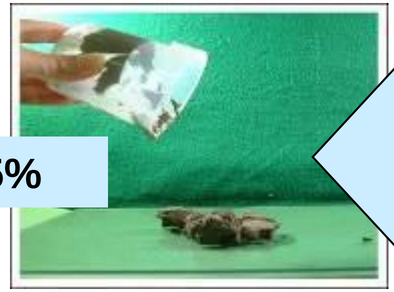
Aggregate : Tight sands, crushed stone, Andesitic crushed stone

SCM : Silica fume, Blast furnace Slag, Fly ash

Nano Mat. : MasterX-Seed

Admixture : PCE Superplasticizer

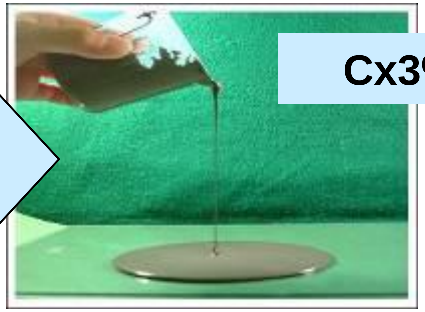
Cx5%



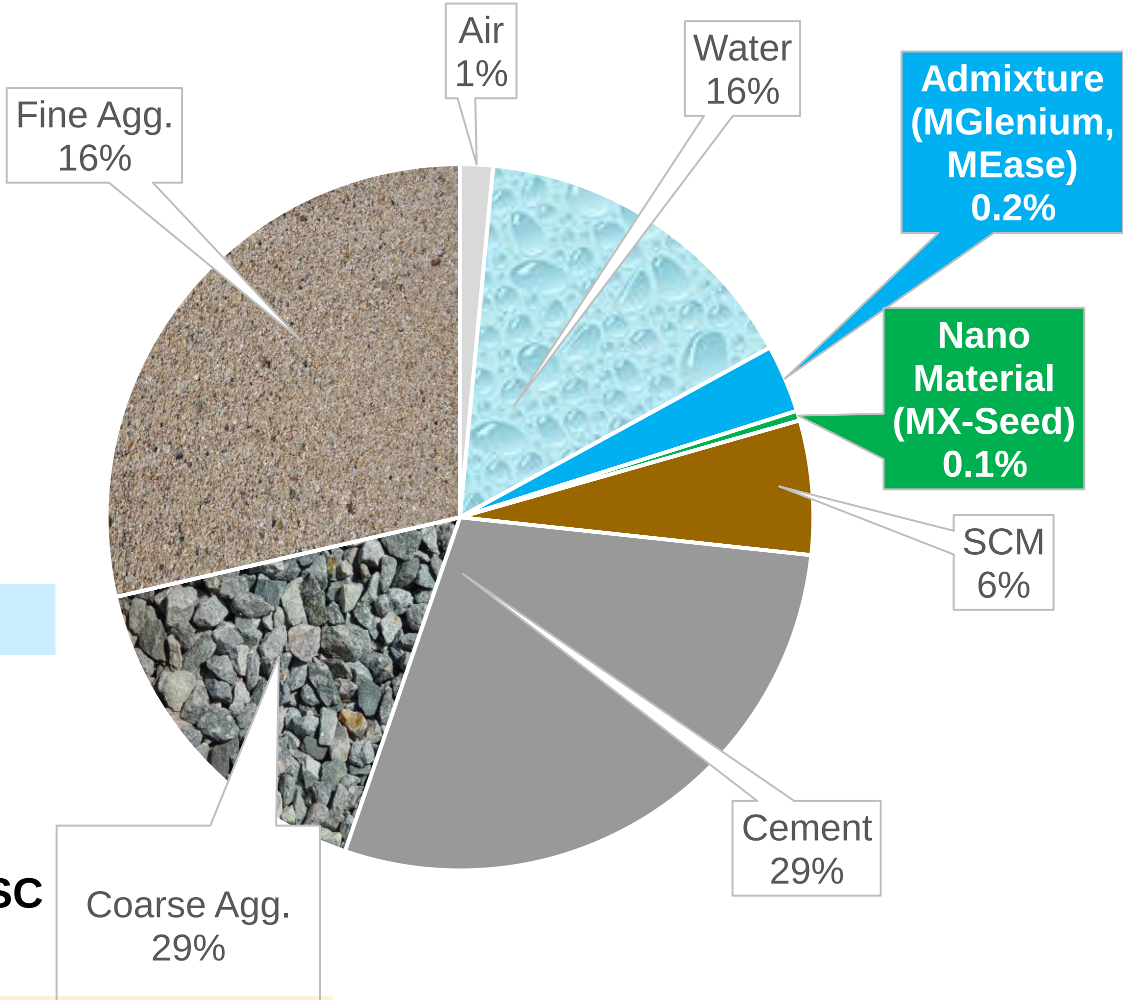
Normal superplasticizer

W/C=15%
Cement paste

Cx3%



Superplasticizer for UHSC



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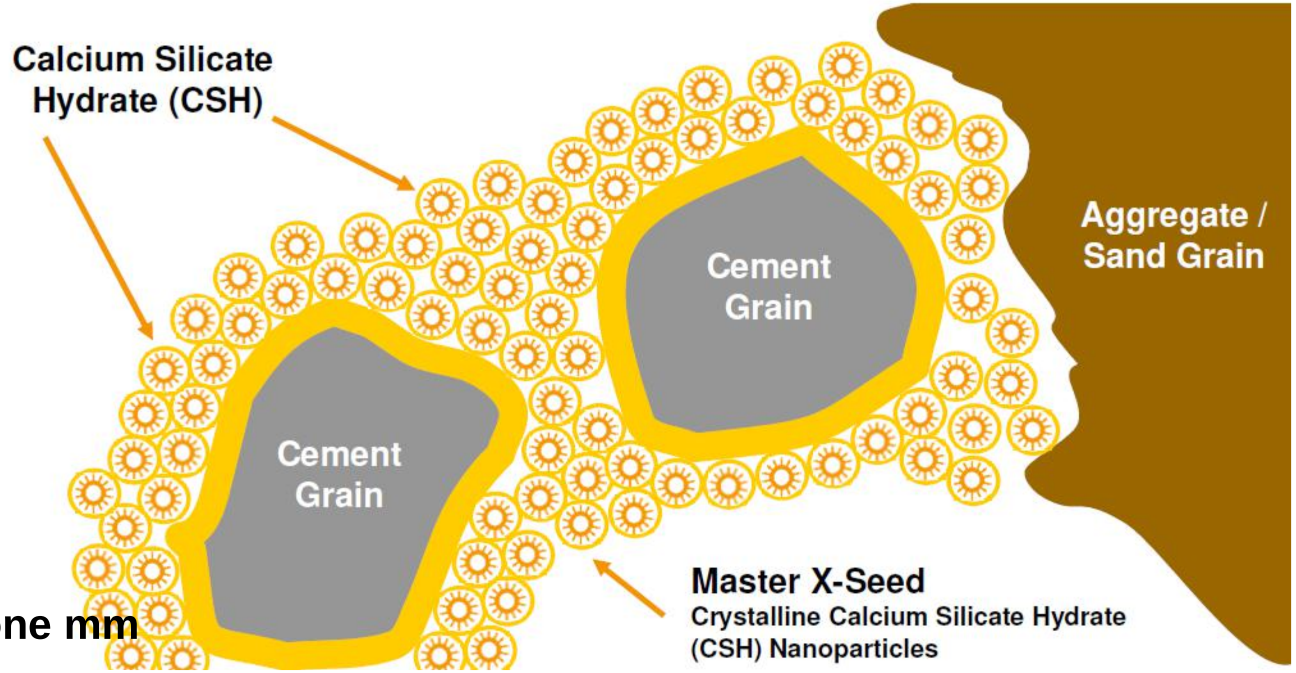
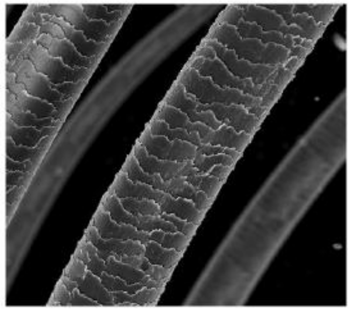
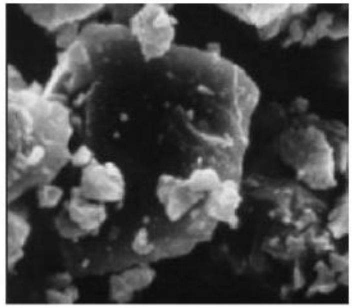


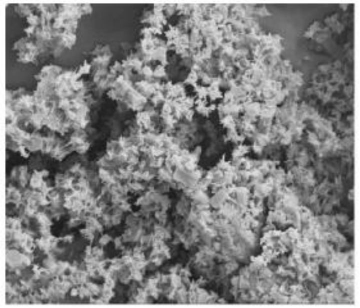
Scale of Thins – Nanometers and More 1,000,000 nm in one mm



Human Hair
~ 50,000 to 150,000 nm



Portland Cement
~ 20,000 to 45,000 nm



Master X-Seed Particles
~ 50 to 100 nm

Ultra High Strength Concrete (UHSC)

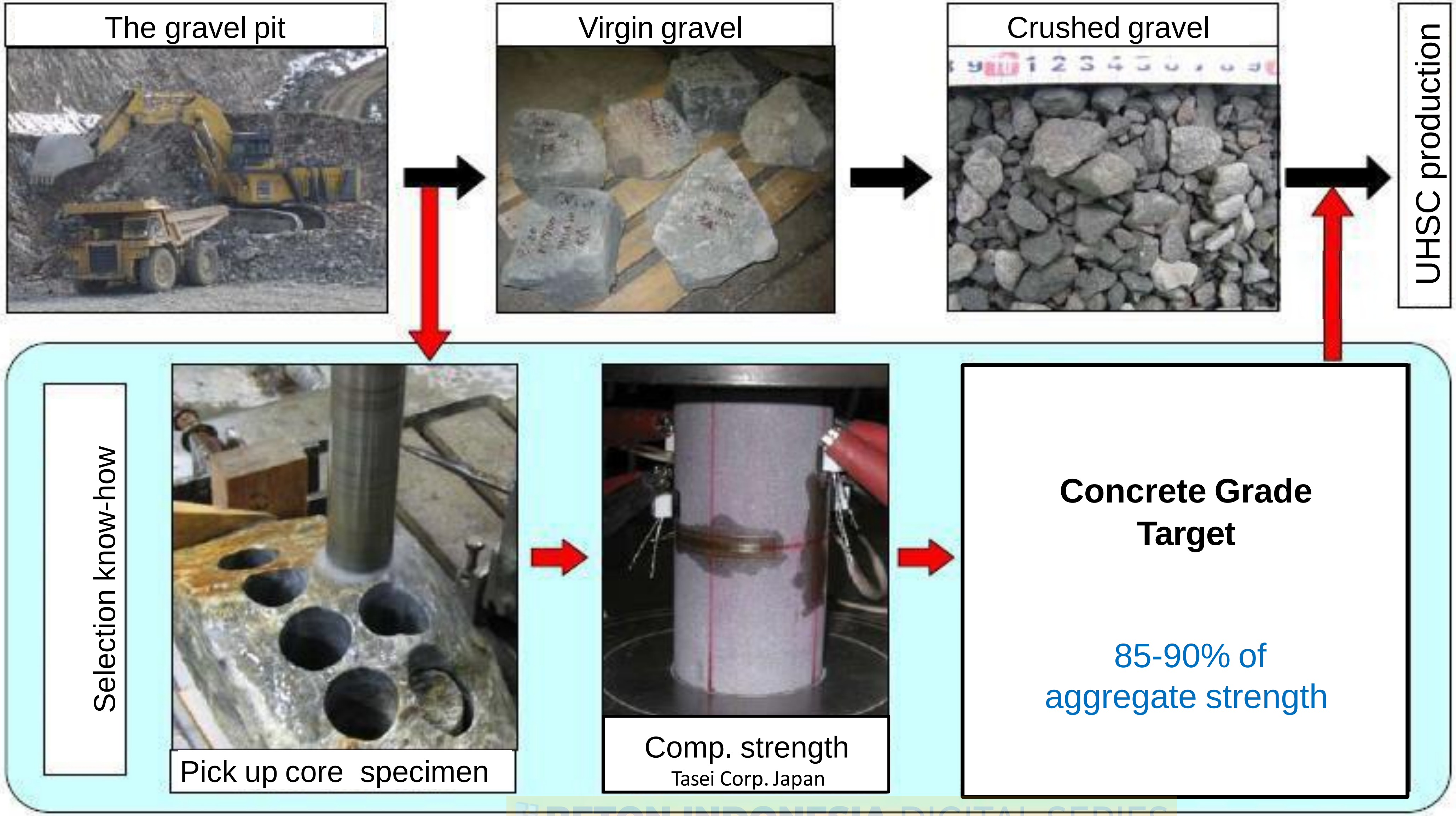
Requirements :

- M 95 grade concrete
- Good Rheology - Non sticky mix
- Three hours of flow retention
- Use of 100% crushed sand
- Flow of 650 mm

WORLD ONE TOWER

- Floors: 117 nos
- Height: 442 m

Step 1- Selection for Coarse Aggregate



(Source: Taisei Corp. TRI)

Step 2 – Mix Design – 95 Mpa

537 kg/m3

88 kg/m3

49 kg/m3

128 kg/m3

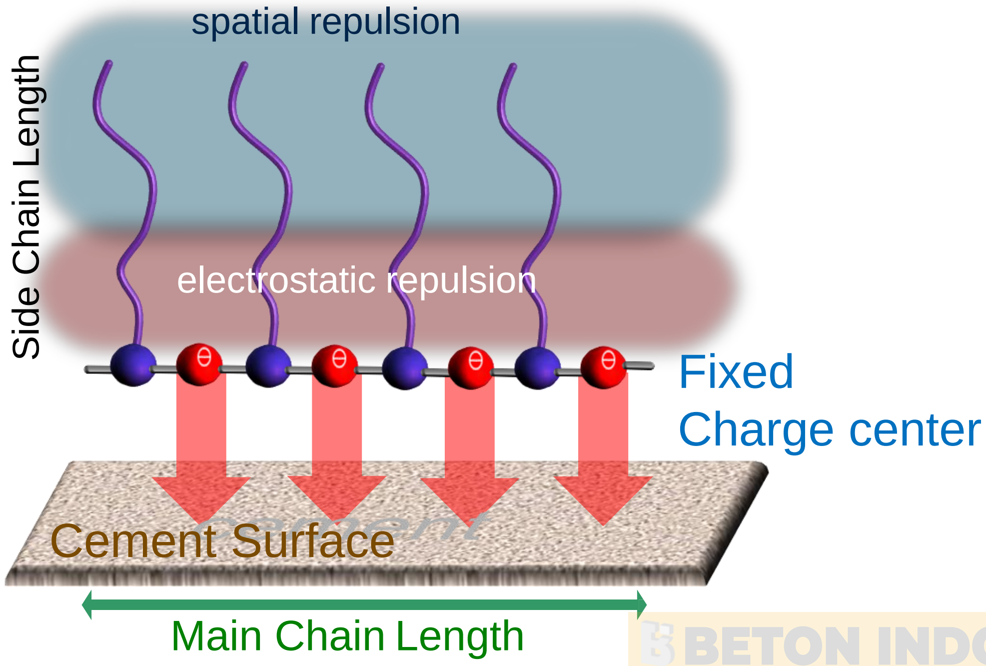
706 kg/m3

1056 kg/m3

Step 3 – Designing for Plastic Properties

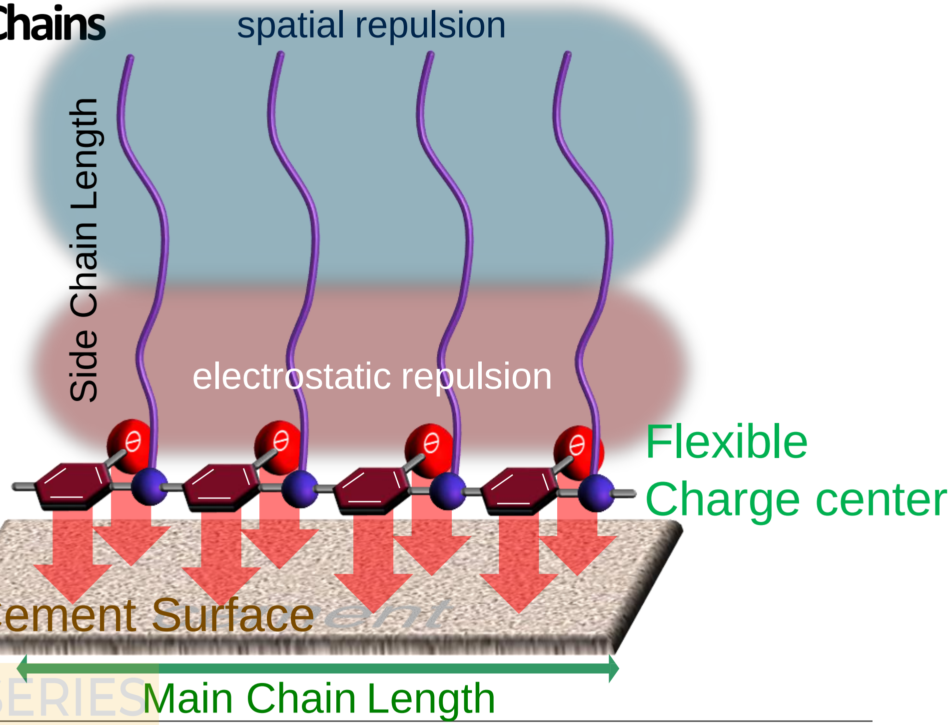
MasterGlenium – PCE Dispersants

- Introduced in the 1996
- Reduces water
- Makes concrete flowable
- "Comb" polymers
- Charge center fixed onto cement surface
- Side Chains



MasterEase – PCE MasterEase Dispersants

- Introduced in the 2016
- Reduces water
- Makes concrete flowable
- "Comb" polymers
- Charge center flexible onto cement surface
- Side Chains

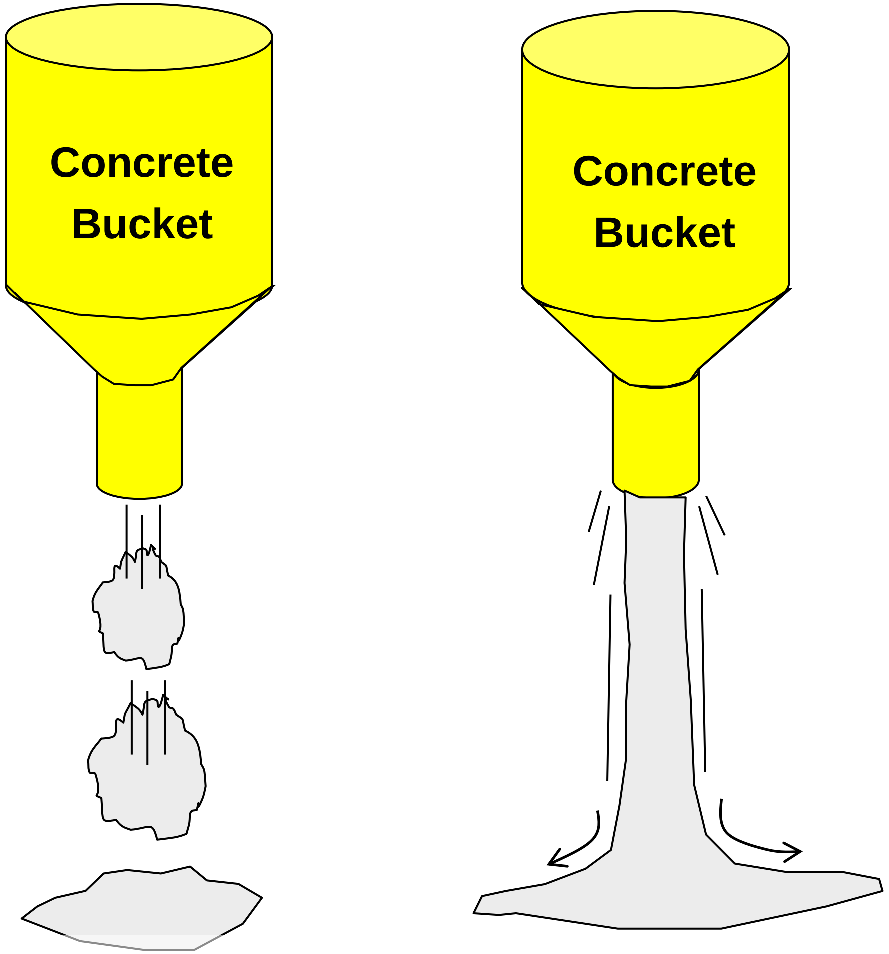


Step 3 – Designing for Plastic Properties

Requirements for Superplasticizer

- High water reduction
- Reduce viscosity
- Dispersion velocity
- Stabilized flowability
- Reduce early age shrinkage after setting (Autogenous shrinkage)

PP adding to UHSC

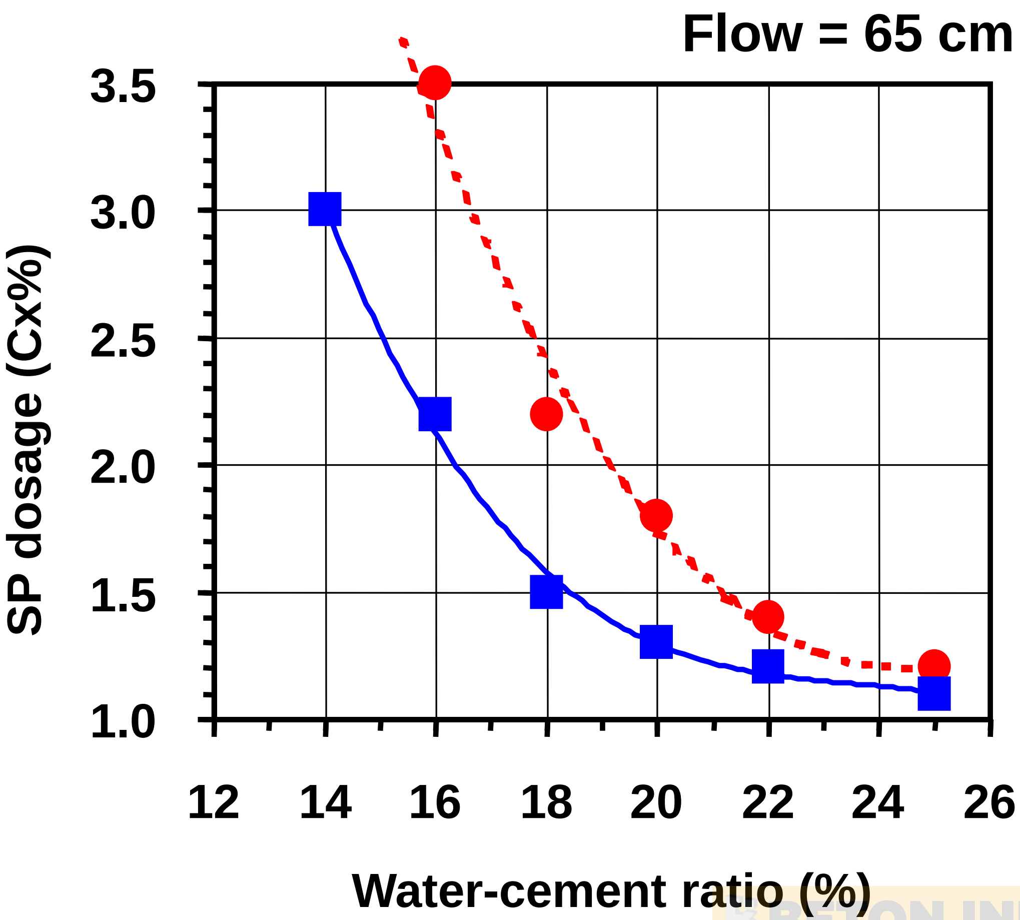


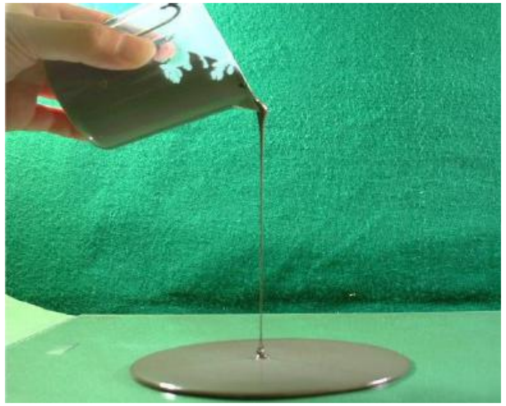
Sticky

Not sticky

Step 3 – Designing for Plastic Properties

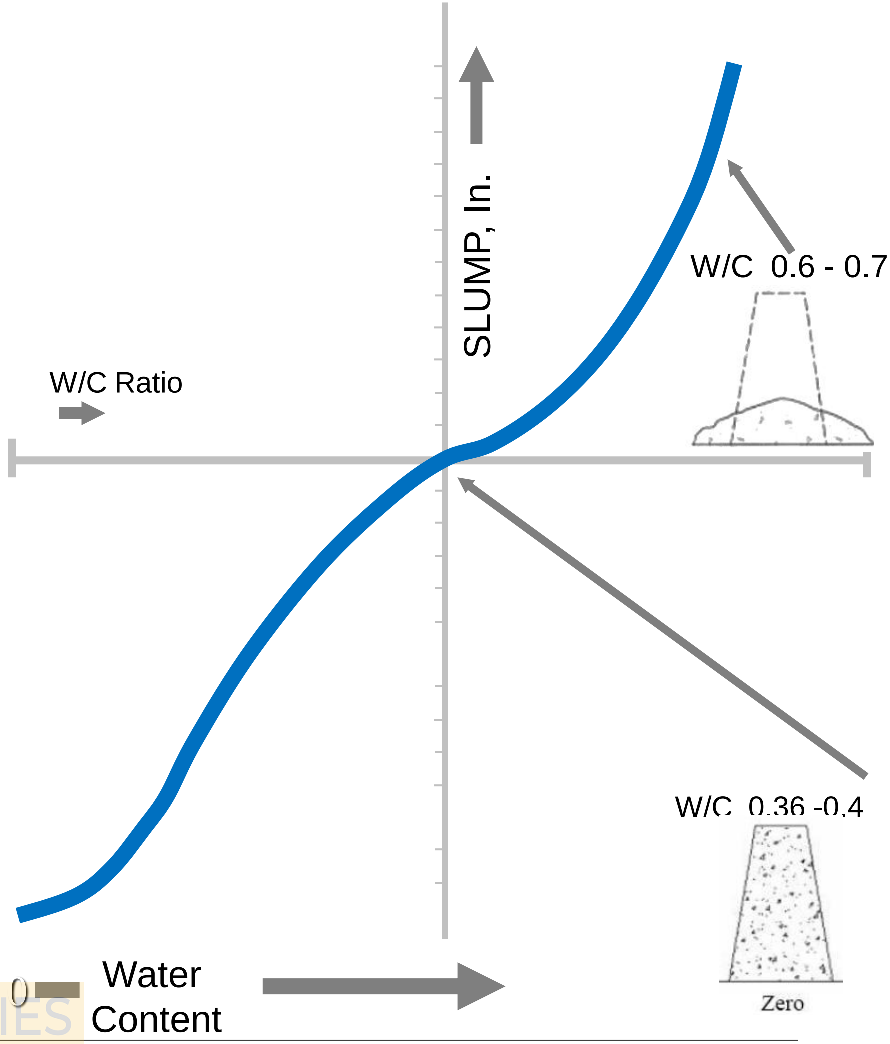
High water reduction - *Conventional PCE vs Glenium 8008*





Conventional PCE

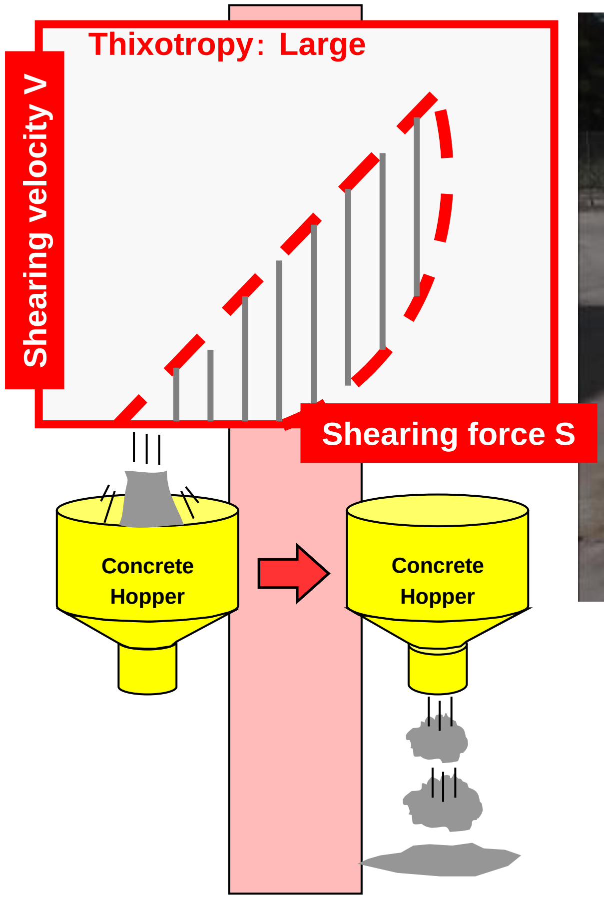
MASTERGLENIUM, MASTEREASE



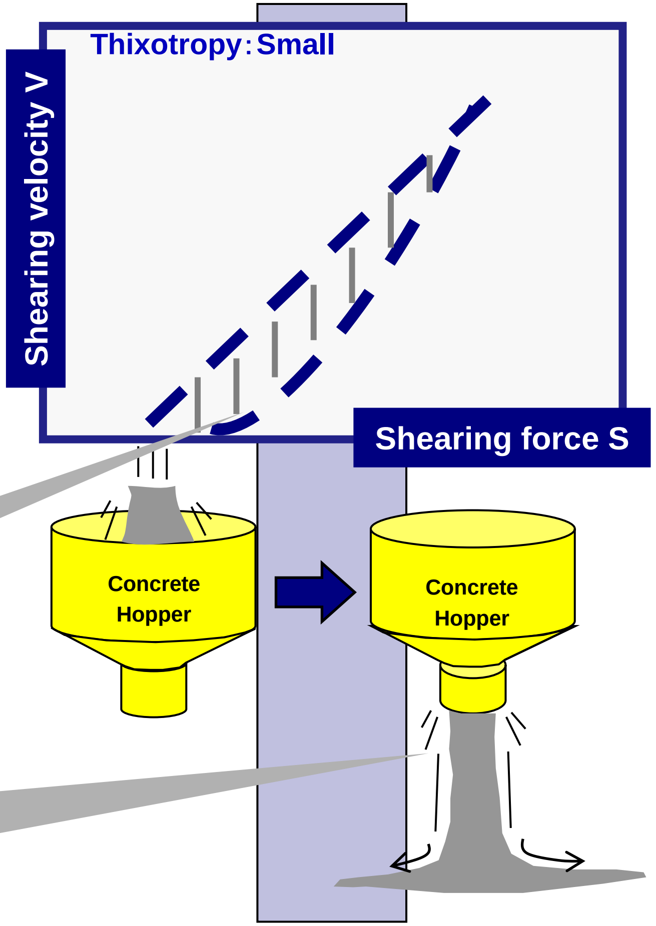
Step 3 – Designing for Plastic Properties

High thixotropy - Key factor influencing flowability of UHSC

Conventional PCE



MASTERGLENIUM® 8008
MASTEREASE® 3500

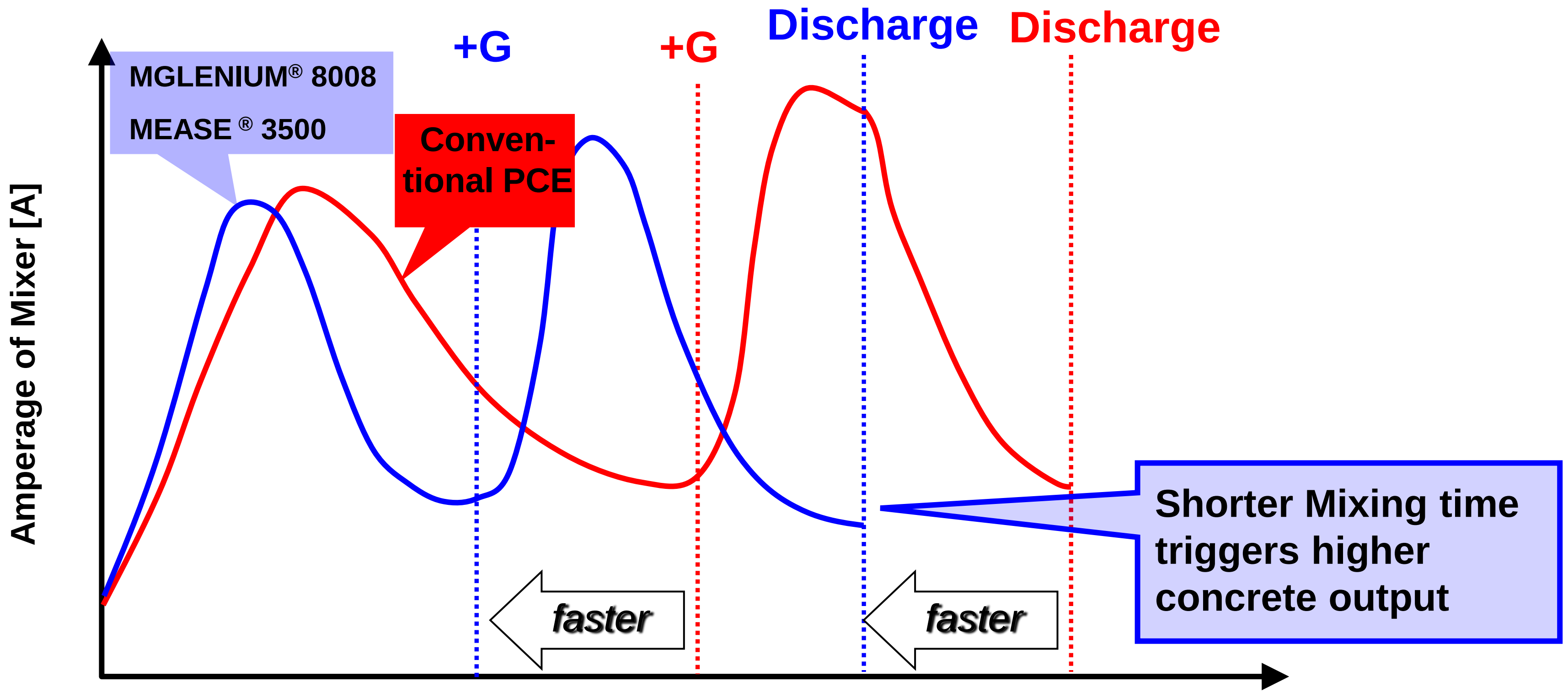


The thixotropy is proportional to the area between the curves.

Concrete with a low thixotropy flows smoothly even if no continuous shear energy is applied.

Step 3 – Designing for Plastic Properties

High thixotropy - Short mixing time at low W/B ratios



Conventional PCE	Mortar (W+AD+C+S) 150sec	Mortar +G 90sec
MGLENIUM® 8008 MEASE ® 3500	Mortar (W+AD+C+S) 90sec	Mortar +G 90sec

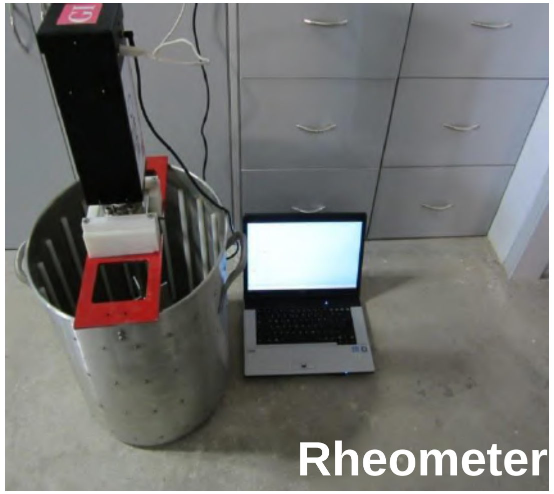
Note: recommended mixing procedure for UHSC

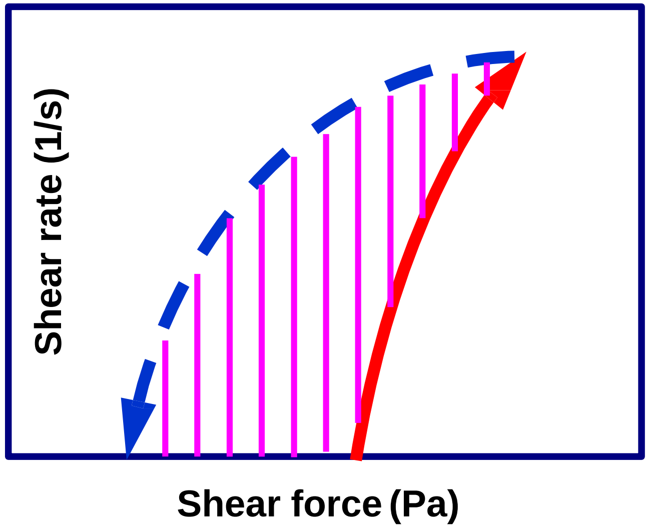
Step 4 – Mixing and Flow Properties

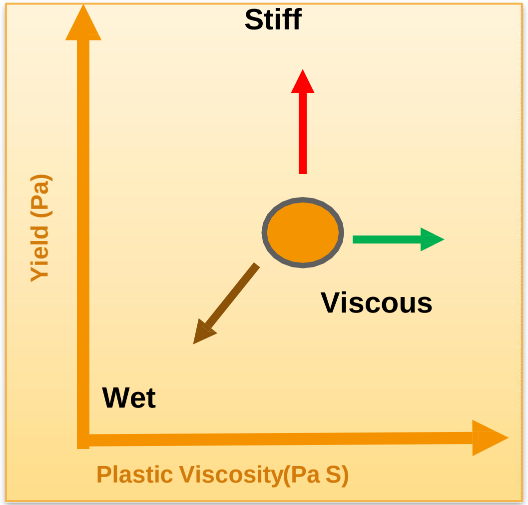
Twin Shaft Mixer

F_c150 — 180s. (S+C+W+SP) → 90s (+G)

F_c130 — 90s (S+C+W+SP) → 90s (+G)







Step 5 – Placing Requirements

- Segregation
- Slump/flow specification
- Temperature of Concrete

- Quality control – moisture
- Pumping
- Curing

95Mpa – Results

750mm

T_{50} = 6 sec

3 h →

750 mm

T_{50} = 6 sec

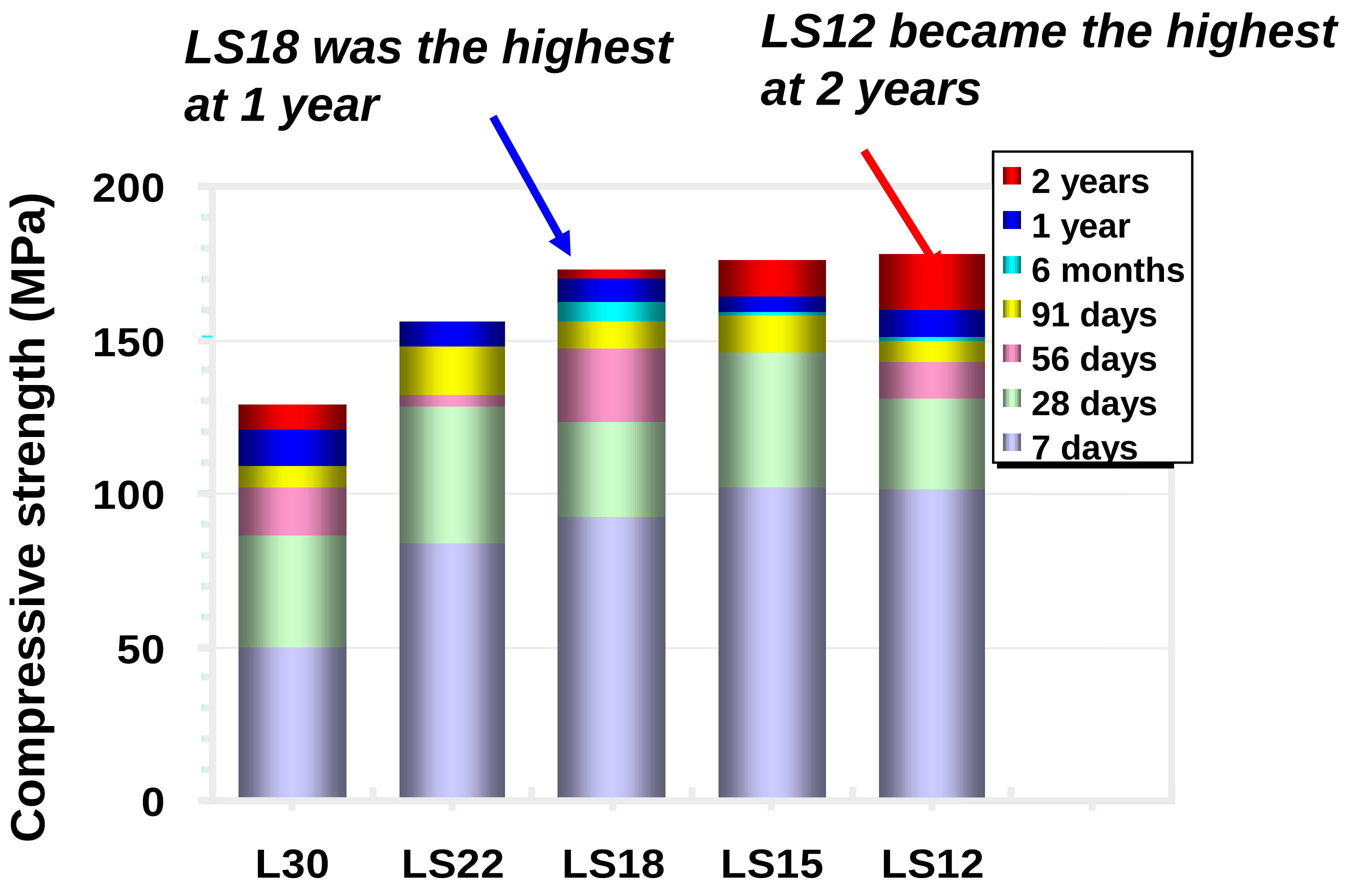
3-day	80 N/mm^2
7-day	97 N/mm^2
28-day	120 N/mm^2

A Study on Compressive Strengths

Symbol	W/B	s/a	Unit content (kg/m³)					SP Dos. (Cx%)	Slump flow (mm)	T_{500} (sec.)
			W	Cement	Silica Fume	Sand	Gravel			
LS12	0.12	0.24	150	1125	125	254	861	4.0	425	-
LS15	0.15	0.36	150	900	100	463	861	2.0	685	19.8
LS18	0.18	0.42	150	750	83	603	861	1.5	700	10.0
LS22	0.22	0.47	150	614	68	729	861	1.2	675	7.5
L30	0.30	0.52	150	533	-	794	861	0.7	675	6.9

UHSC hardened property

Compressive strength under standard curing



Symbol	*W/B*
LS12	0.12
LS15	0.15
LS18	0.18
LS22	0.22
L30	0.30

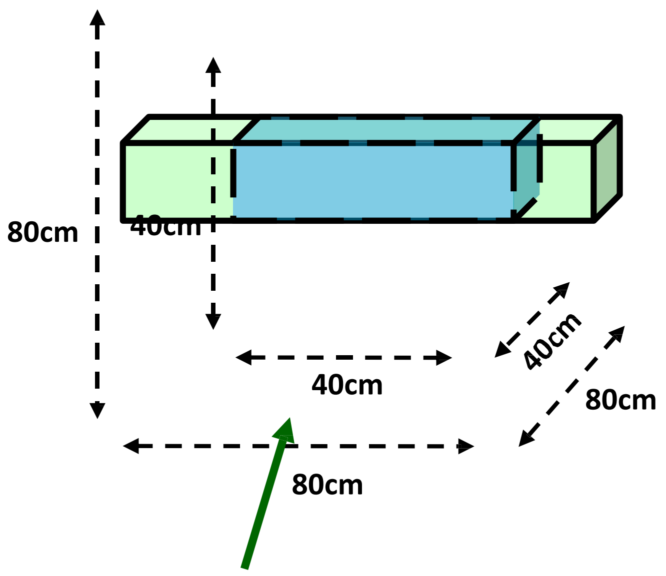
It needs 2 years to develop the potential strength for its W/B cured by standard method

Adiabatic Curing Experiment

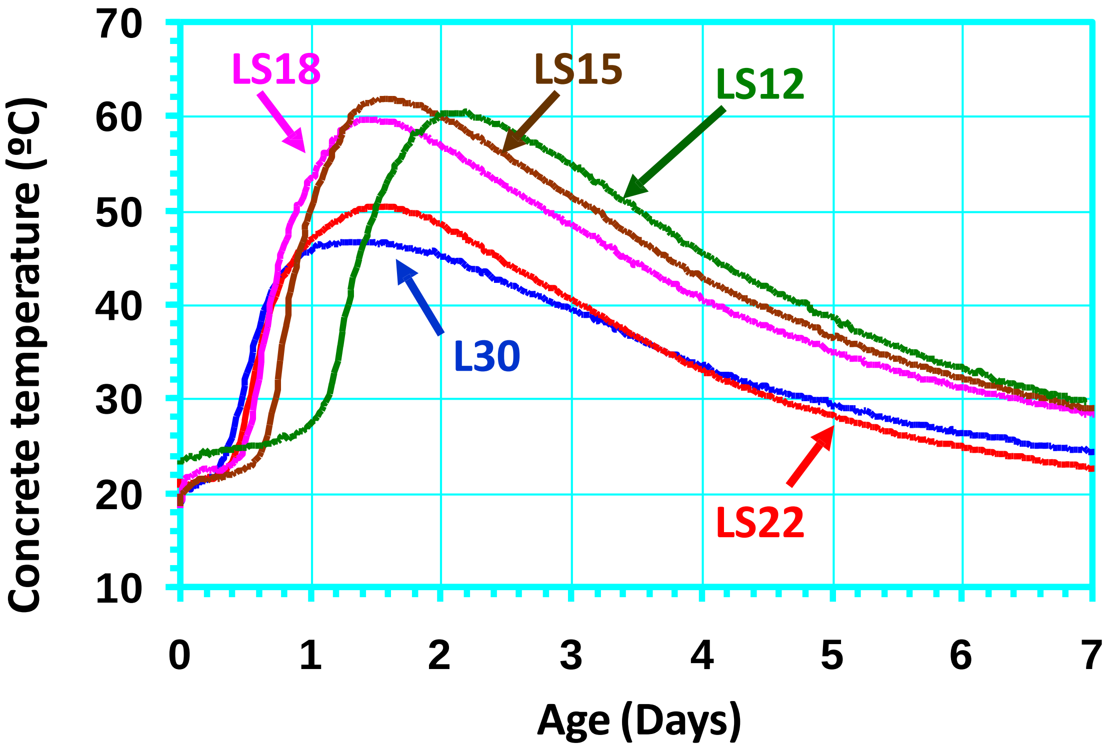
7 days → 20 ºC

Sealed curing until 28, 56 days

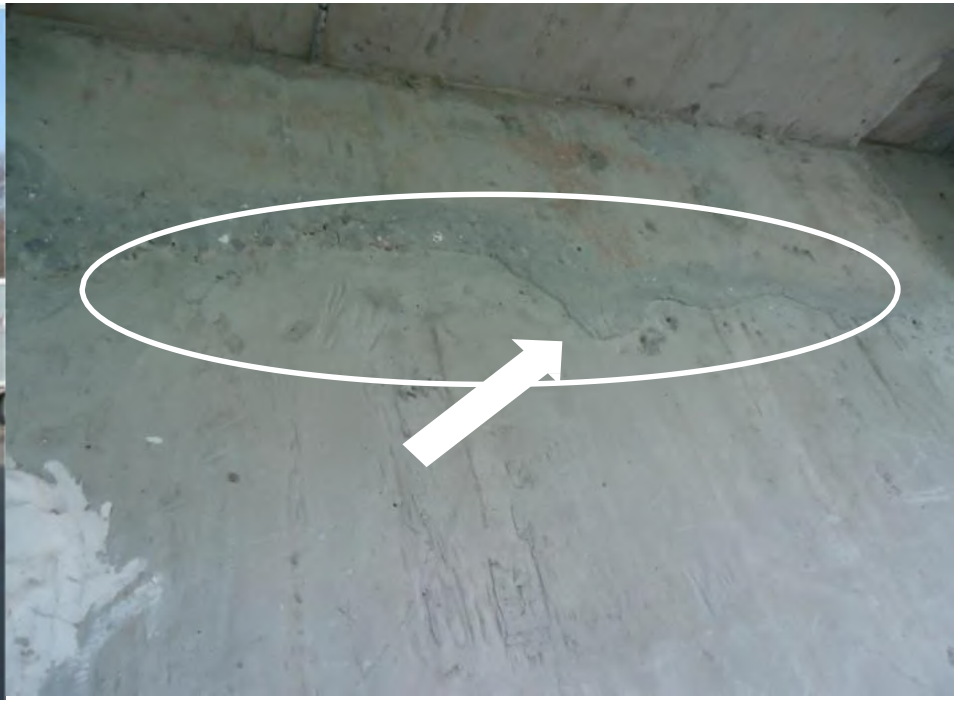
Diameter 10 cm x 20 cm high
10 specimens



Heat Insulating box



Durability – Cracking in Structures



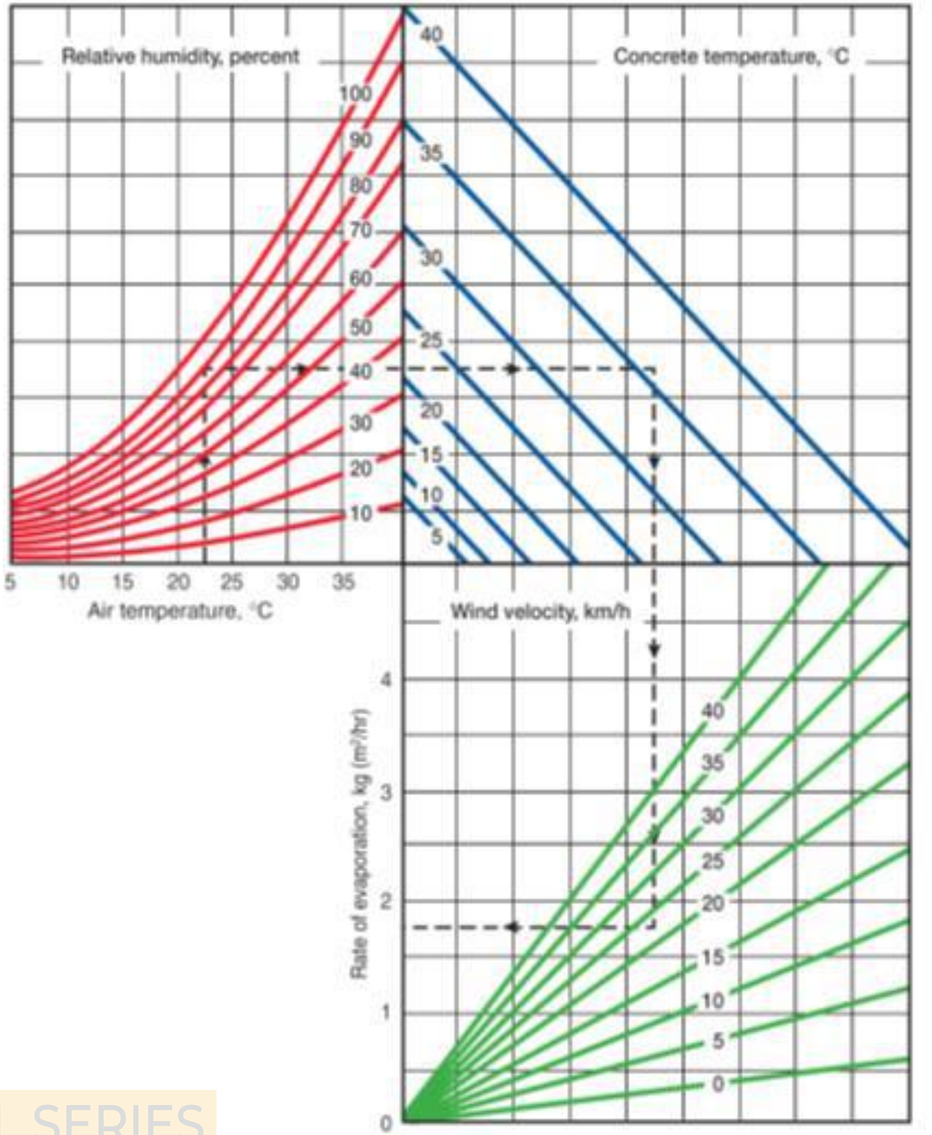
Durability - Cracking in Structures

Shrinkage Cracking

- **Autogenous**
- Plastic
- Drying

Thermal Cracking

- Mass of concrete section
- Concrete temperature
- Temperature differential



Thermal Cracking – Considerations

Concrete T

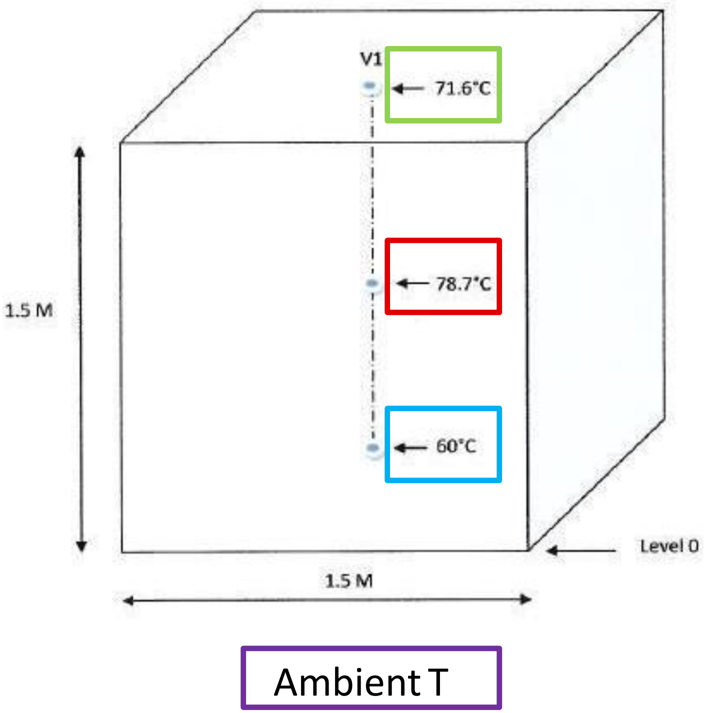
- Shall not exceed 70 C

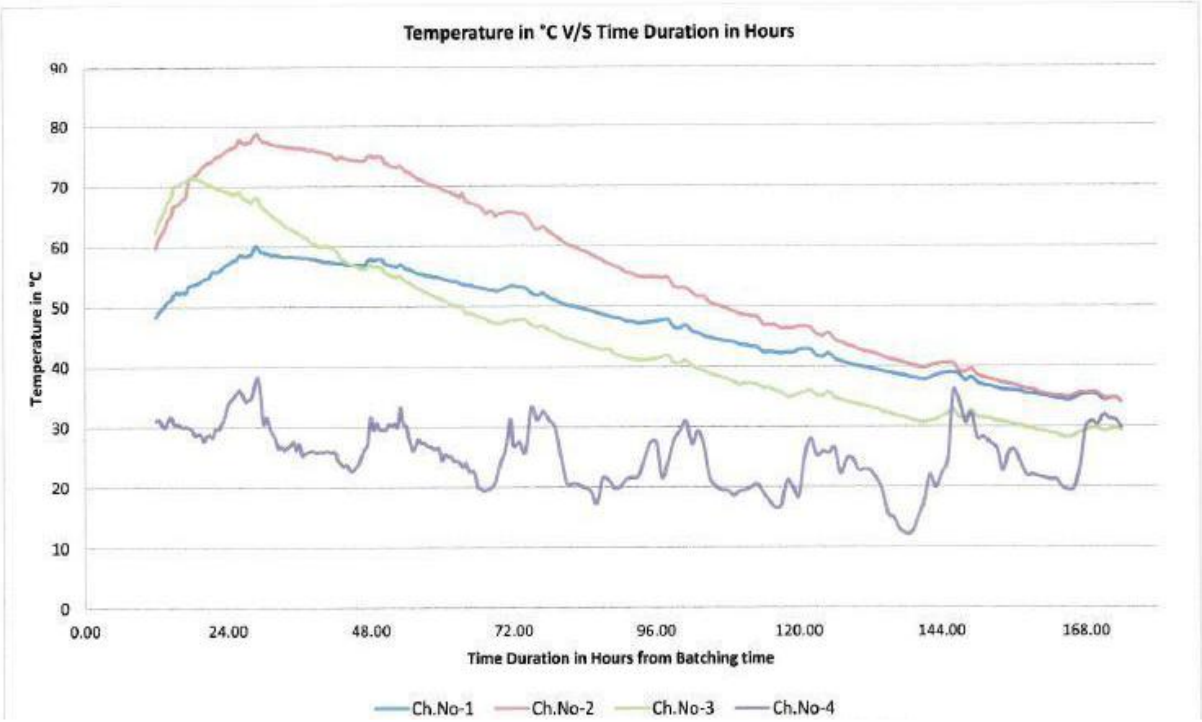
T differential

- Shall not exceed 20 C

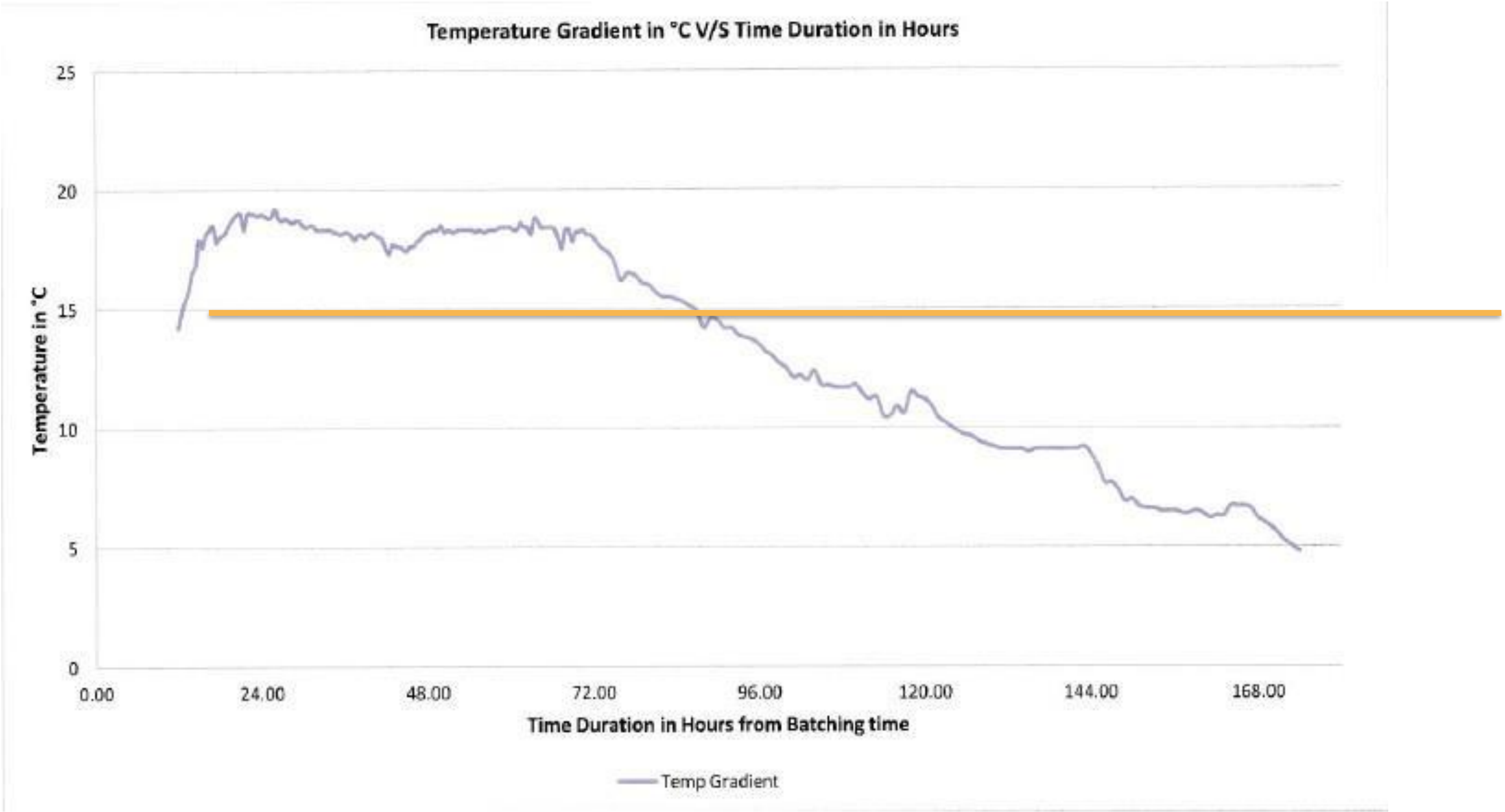
CIRIA 1995

Mass Concrete – Mock Up Studies





Mass Concrete – Mock Up Studies



Preventing Thermal Cracking – Guidelines

Slag and Fly Ash Replacement Guidelines

Pour Thickness (m)	%GGBS (min)	%Fly Ash (min)
< 1.0	40 %	20 %
1.0 - 1.5	50 %	25 %
1.5 - 2.0	60 %	30 %
2.0 - 2.5	70 %	35 %

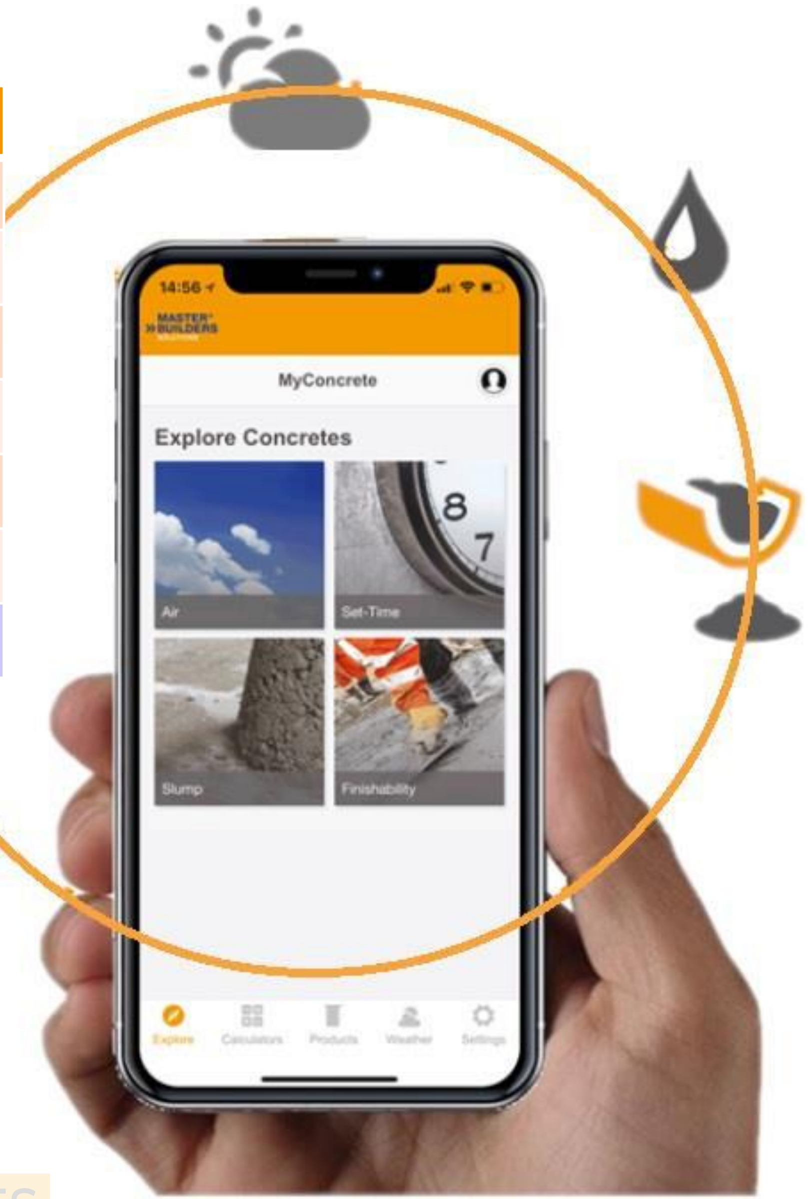
Time for Insulation (▲T)

Pour Dimension (minimum)	Insulation Time (minimum)
0.5 m	**3 days**
1.0 m	**5 days**
1.5 m	**7 days**
2.0 m	**9 days**
2.5 m	**11 days**

CIRIA 1995

Controlling Concrete Temperature

RM	Weight	Temperature in °C					
Cementitious	674	45	45	45	45	45	45
20 mm	0	35	35	35	35	35	15
10mm	1056	35	35	35	35	35	15
Sand	706	35	35	35	35	35	35
Water	128	27	4	27	27	4	4
Ice Repl. %		0	0	50	80	80	80
Concrete T		**36**	**31**	**26**	**21**	**19**	**10**



$$\text{Temp. of concrete (T)} = \frac{0.22\,(Ta.Wa + Tc.Wc) + (Ww - Wi)Tw + Wwa.Twa - 79.6.Wi}{0.22(Wa + Wc) + Ww + Wi + Wwa}$$

Where,
T = temperature of freshly mixed concrete (°C)
Ta, Tc, Tw, Twa = temperature of aggregate, cement, added mixing water and free water on aggregate

Wa, Wc, Ww, Wwa, Wi = weight of aggregate, cement, added mixing water, free water on aggregate, ice

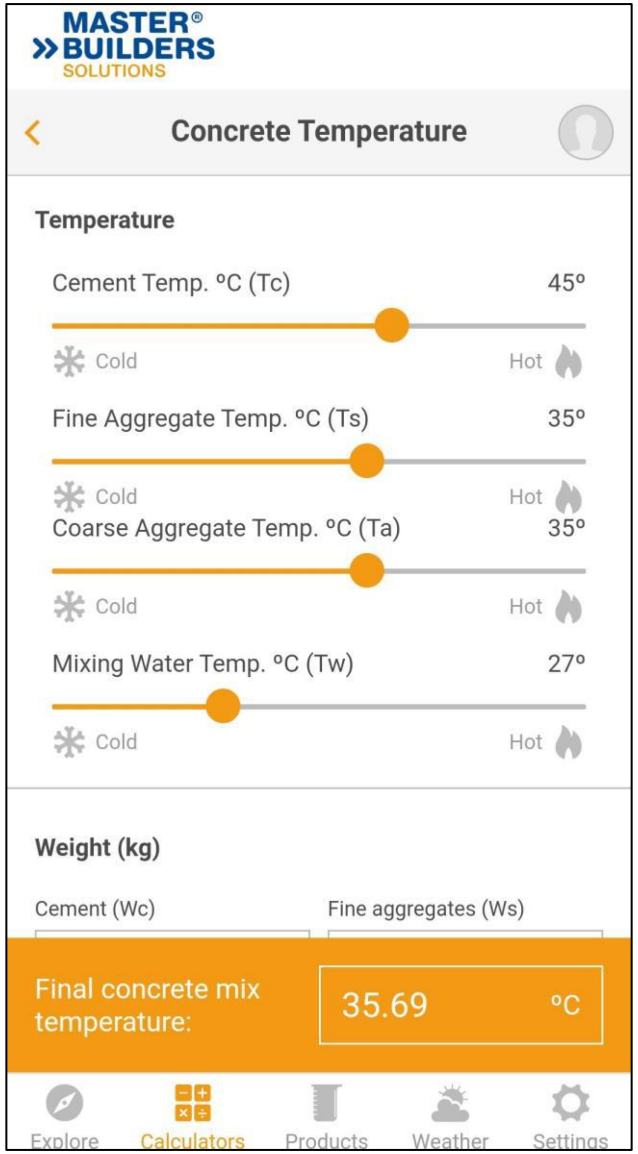
Controlling Concrete Temperature

RM	Weight	Temperature in °C					
Cementitious	674	45	45	45	45	45	45
20 mm	0	35	35	35	35	35	15
10mm	1056	35	35	35	35	35	15
Sand	706	35	35	35	35	35	35
Water	128	27	4	27	27	4	4
Ice Repl. %		0	0	50	80	80	80
Concrete T		**36**	**31**	**26**	**21**	**19**	**10**

$$\text{Temp. of concrete (T)} = \frac{0.22\,(Ta.Wa + Tc.Wc) + (Ww - Wi)Tw + Wwa.Twa - 79.6.Wi}{0.22(Wa + Wc) + Ww + Wi + Wwa}$$

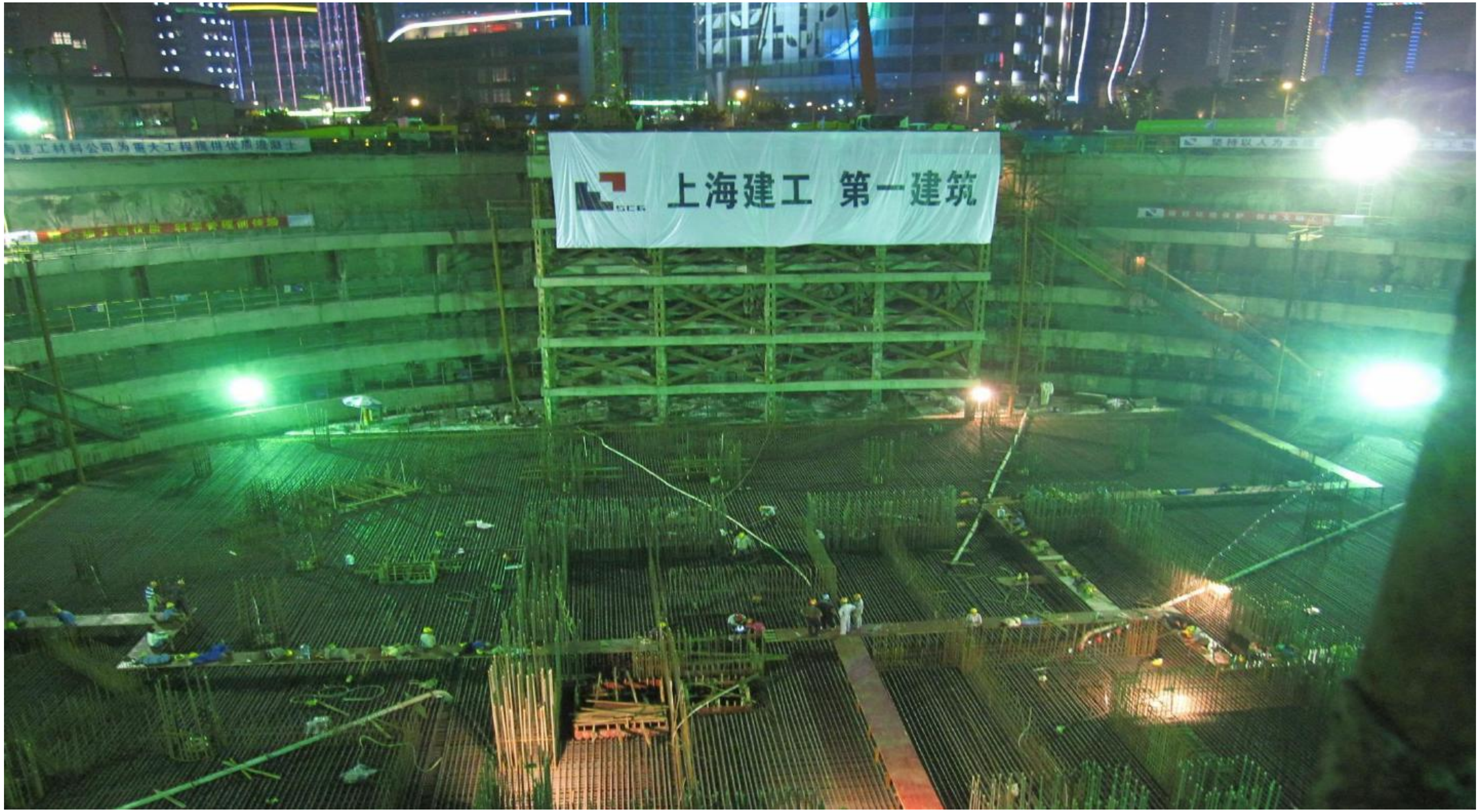
Where,
T = temperature of freshly mixed concrete (°C)
Ta, Tc, Tw, Twa = temperature of aggregate, cement, added mixing water and free water on aggregate

Wa, Wc, Ww, Wwa, Wi = weight of aggregate, cement, added mixing water, free water on aggregate, ice



Case 1 - White Magnolia Plaza

Puxi, Shanghai



White Magnolia Plaza
Puxi, Shanghai

Contractor: SCG

Volume of concrete : 20,000 m^3 in raft foundation

Depth of foundation : 4.2 m

Concrete mix : Cement (260 kg/m^3) + Slag (120) + Fly ash (80)

Water / binder : 0.33

Slump : 180 mm

Maximum Ambient temperature : ~35 degrees Celsius

Maximum temperature : 72 degrees Celsius

Case 2 - Raft foundation Shanghai Tower

Raft dimensions:

Volume 60,000m^3, Height - 6m, dia - Φ 120m

Requirements: **M 50**

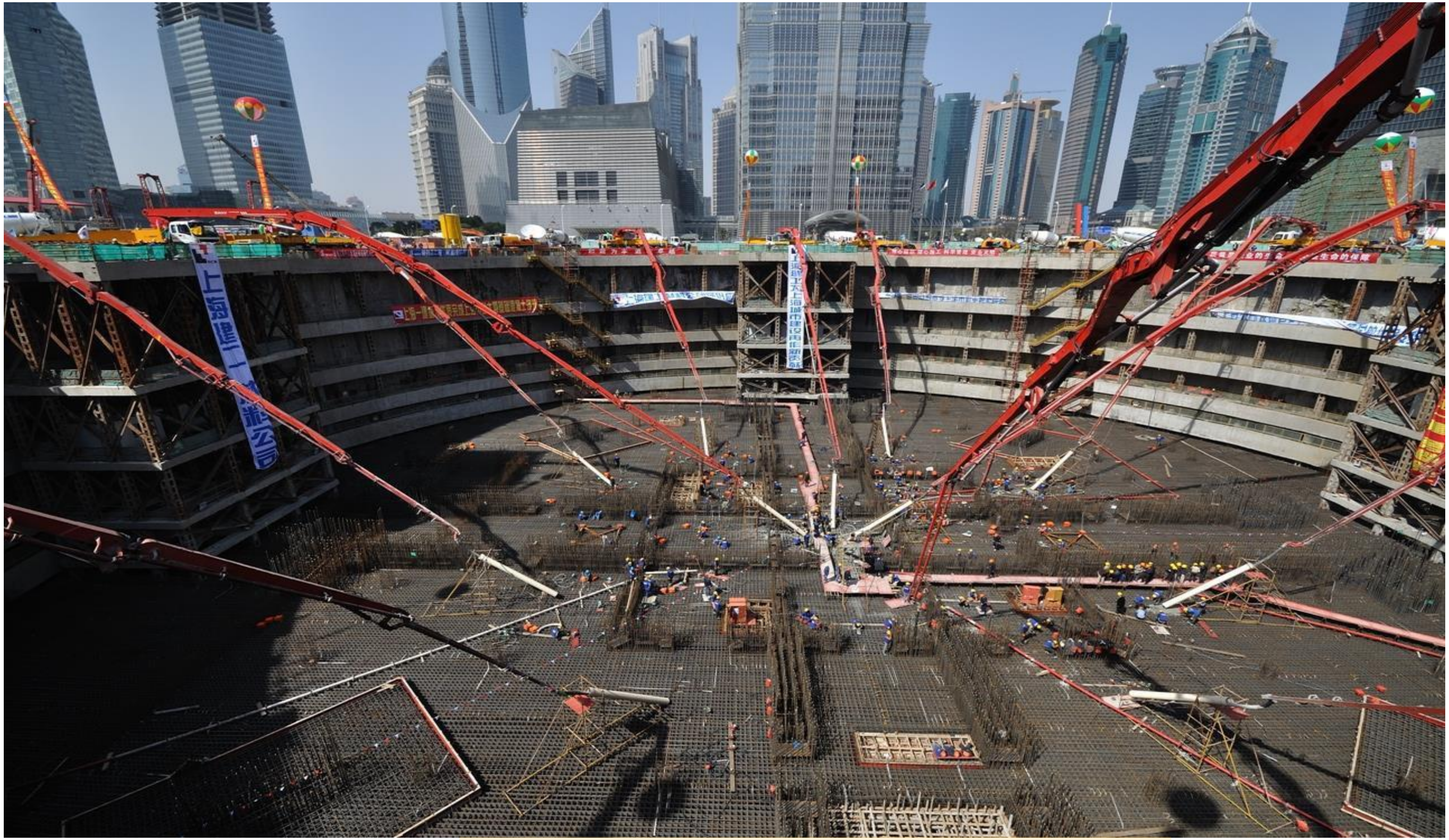
- Temperature control of concrete
- Heat of hydration control
- Triple blend mix of OPC + PFA + GGBFS
- Peak temperature below 76 °C

Concrete Mixture Design:

Water kg/m^3	Cement kg/m^3	Slag kg/m^3	Fly ash kg/m^3	Sand kg/m^3	Stone kg/m^3	
160	240	120	80	760	1000	

42

Shanghai Tower - Raft Pour



Case 3 - Raft foundation Burj Khalifa

- **Raft dimensions:**

  Volume 12,500 m^3, Height – 3.7 m

  M50 Grade Concrete SCC

- **Other Requirements:**

  - 3 hours workability retention
  - 80 N/mm^2 at 28 days
  - Pumpable to 600 m+
  - 10 N/mm^2 at 12 hours
  - Consistent Performance year-round

- **Concrete Mixture Design**:

Water kg/m^3	Cement kg/m^3	Silica Fume kg/m^3	Fly ash kg/m^3
144	252	30	168

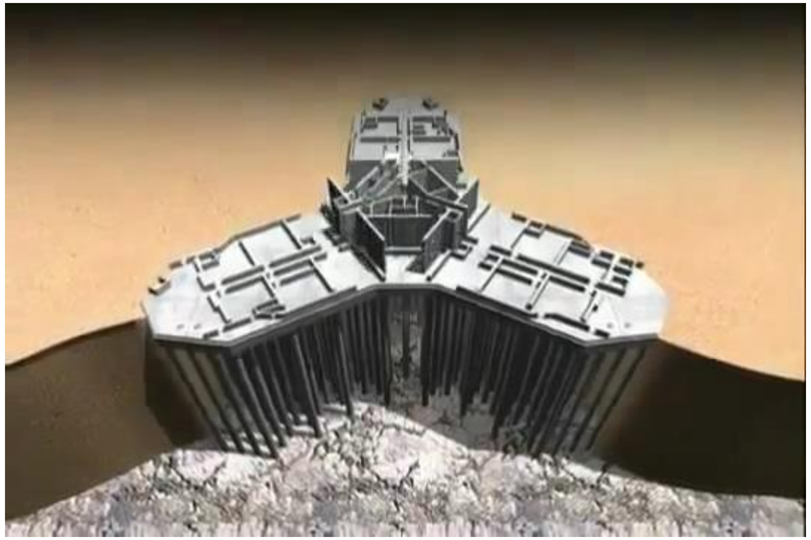
4
4

Case 3 - Burj Khalifa Pumping Concrete

C80/C60 Concrete Design: (kg/m3)

(kg/m³)	C80/20	C80/14	C60/14
OPC	380	384	376
PFA	60	96	94
Silica Fume	44	48	25
Free water (lt/m³)	132	155	166
Glenium (lt/m³)	4.50	3.75	3.50

World Record Pumping Vertical Height of 601 m

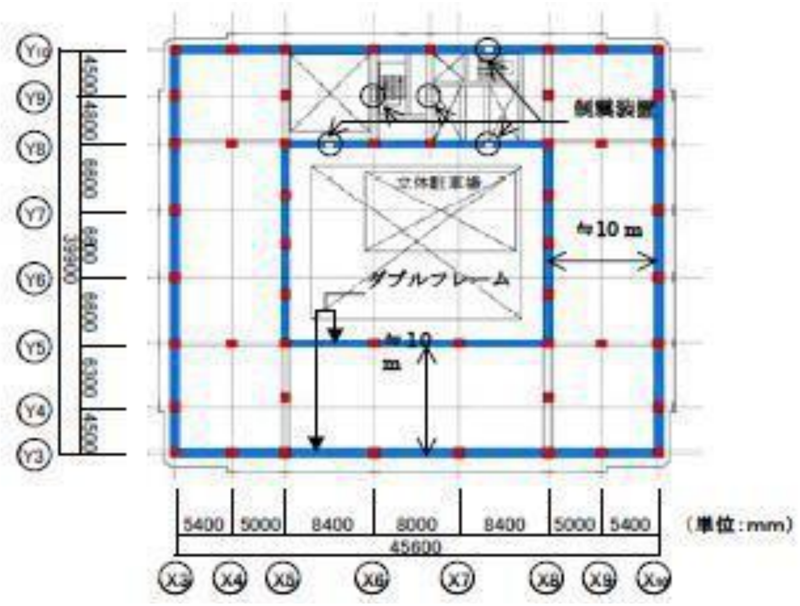


Pumping Simulation

Case 4 - UHSC in Japan

Wide living space which has no column and no beam can be achieved with ultra high strength concrete.

10m spans were possible at KOSUGI TOWER using **150MPa** concrete.



Column distribution plan

Case 4 - Brillia Tower, Tokyo

Source: Kuroiwa et al., Concrete Engineering, Vol. 42, No.10, pp.44-49, 2004/10

Project overview (completed 2006)

- Site: Kinshi-cho, Tokyo (159m/45F/644 unit)
- Contractor: TAISEI Corp.
- Column for 1~3 floor is C130 concrete, 700m^3
- Column for 4~9 floor is C100 concrete
- T_{50}<10 sec w/o fibers; T_{50}<25 sec w/ fibers

Design		Fc (MPa)	W/B (%)	Unit (kg/ m^3)					
flow (cm)	Air content (%)			water	binder	sand	stone	Glenium 8008	fiber
65	1.0	130	18.0	150	834	647	835	12.9	2.5

C130 Concrete Design: (kg/m3)

Case 4 - UHSC allows thin sections

No conventional reinforcement but steel fibres

F_C >180 N/mm²
σ_2 >80 N/mm²

Case 5 – UHSC in China

Guangzhou IFC

Project overview

- Site: Zhujiang New City, Guangzhou (103F, 432 meter)
- Developer: Guangzhou Yuexiu Civil Construction Group
- Contractor: China Construction Engineering Co. & Guangzhou Construction Group
- C90 pumped to 167m
- C80 pumped to 410m
- >C60 concrete up to 70,000m³

Guangzhou West Tower

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