HIGH PERFORMANCES

CONCRETE

Jean-Michel Laye Head QC – Product Development Lafarge India

World leader in building materials

- **Leadership positions in all our Businesses**
  - World leader in Cement
- Operating in **79** countries
- Employing **84,000** people
- **2,200** industrial sites worldwide

- World No.2 in Aggregates and No.3 in Concrete
  - 620 quarries and 1,325 concrete plants in 40 countries
- Strong positions in Aggregates in France, UK, Canada, US
- Acceleration of our development in emerging markets
  - Solid positions in South Africa, Poland, Ukraine
  - **India : 80 RMX plants – 3.5 – 4 millions M3 of concrete**
    - **<u>2.2 Cr liters of admixtures</u>**

Lafarge R&D

- Long term presence in Cement, Concrete, Aggregates and Gypsum explains our unique multi-disciplinary expertise
- 20 years of development of our scientific approach
- The largest research center in building materials

220 employees - 12 nationalities – 70 PhD
Budget : 25 M Euros funded by 3 divisions and corporate

Building of 2.500 m^2 dedicated to concrete R&D

HIGH PERFORMANCES

CONCRETE

Definition of High Performance Concrete

- **Compressive Strengths above 50 Mpa and up to 100 /110 Mpa**
- **Modulus of Elasticity above 35 / 40 Gpa**
- **High level of Durability (Permeability / RCPT / Carbonation / Corrosion)**
- **Use of 2 or 3 cementitious materials**
  - » **Microsilica**
  - » **Fly ash (processed)**
  - » **GGBS**
  - » **Metakaolin**
  - » **Limestone filler / siliceous filler**
- **Use of High Water reducer admixtures**
  - » **at least one type of PCE**
  - » **and /or Poly-phosphonate type and a retarder**
    - **In order to achieve very low W/C , workability and slump retention AND PUMPABILITY**

Parameters

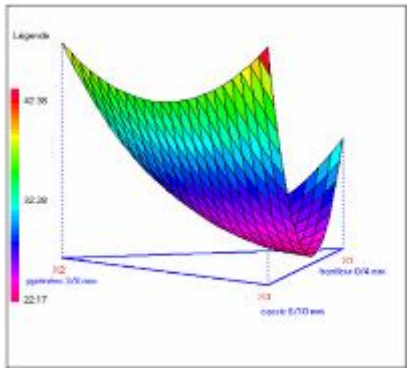
- A granular skeleton
  - **Aggregates, sand, fines, ultra-fines…**
    - Particle size distribution / gradation
    - Packing density
    - + Absorption
    - + Chemical interaction

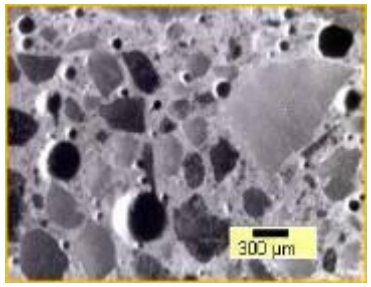
(clays, chlorides, reactive silica, organic elements,…)

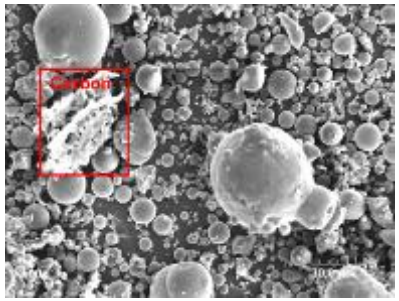
- A paste
  - **Binder (cement + additions), water, air and admixtures**
    - Particle size distribution
    - Packing density
    - Effective water
    - Binder quantities and interactions
    - Air content
    - Admixtures

Performances

- Rheology
  - Packing of solid particles
  - Paste content
  - Water content
  - Admixtures
- Strength (early age and final)
  - Binder composition
  - Water-to-binder ratio
  - Packing of solid particles
- Durability
  - Binder composition
  - Water-to-binder ratio
  - Air entrained

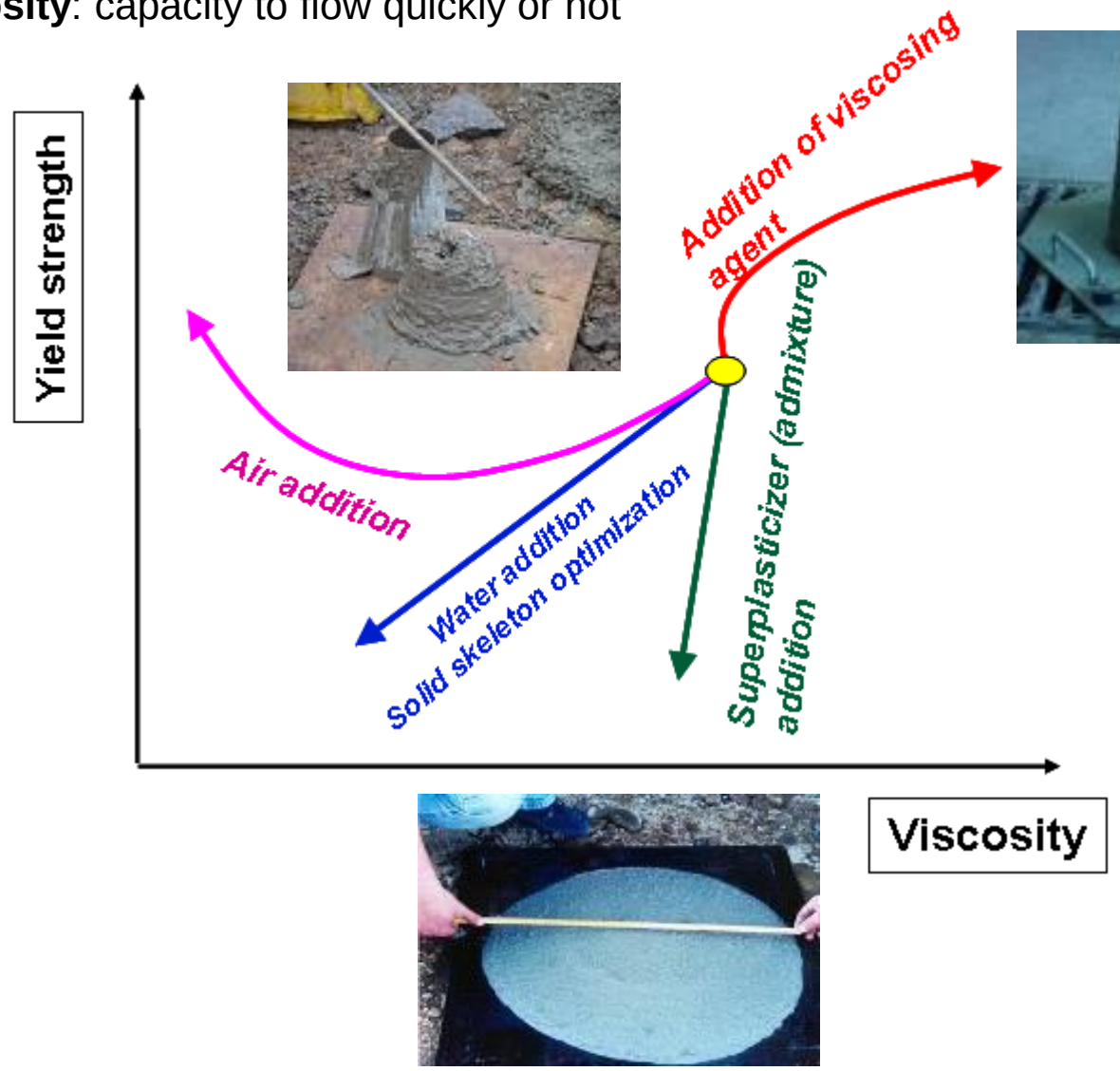






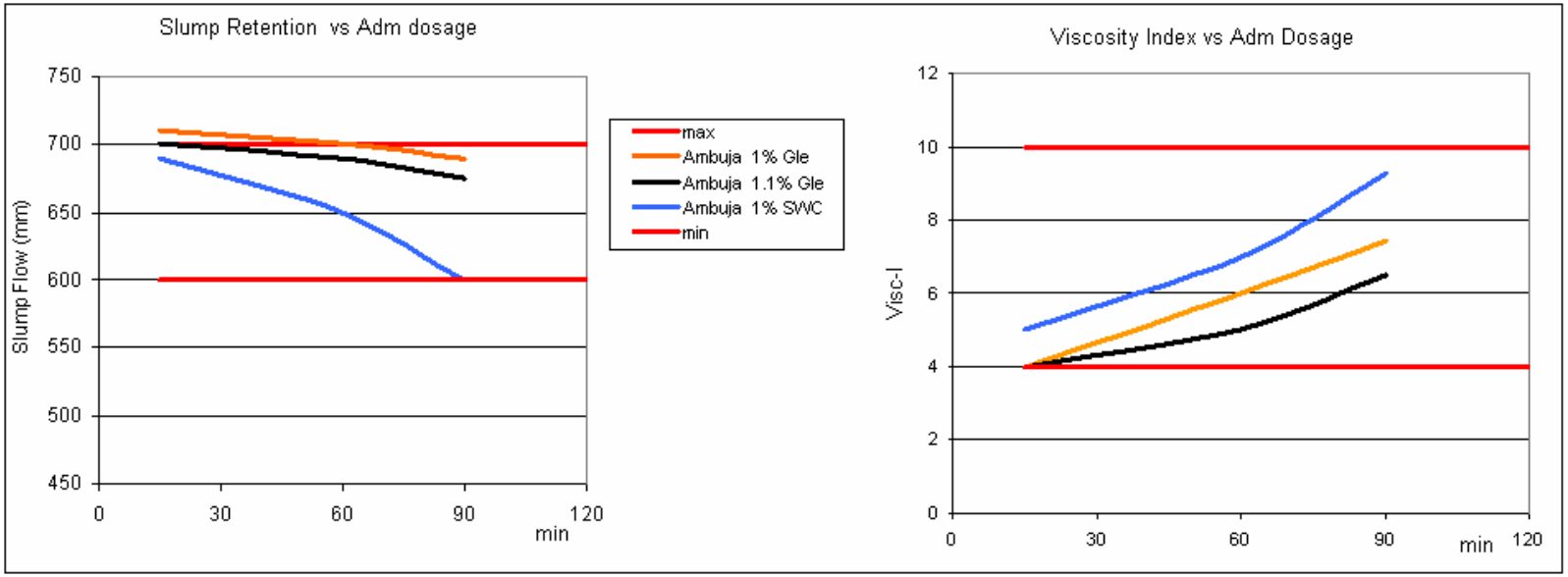
Workability

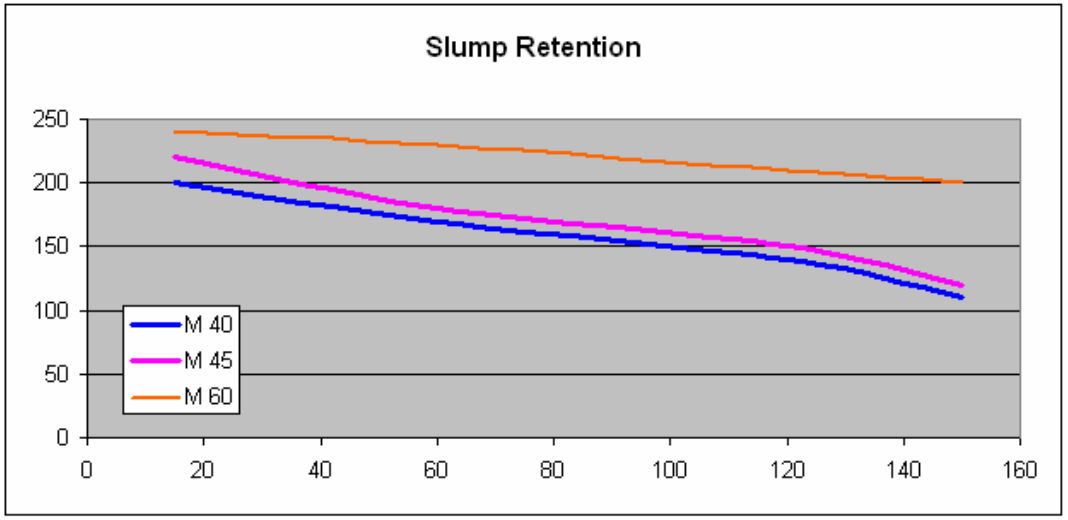
- **Yield stress** : indication on the capacity to maintain its own shape
- **Viscosity**: capacity to flow quickly or not



Workability

Slump / Slump flow and Viscosity

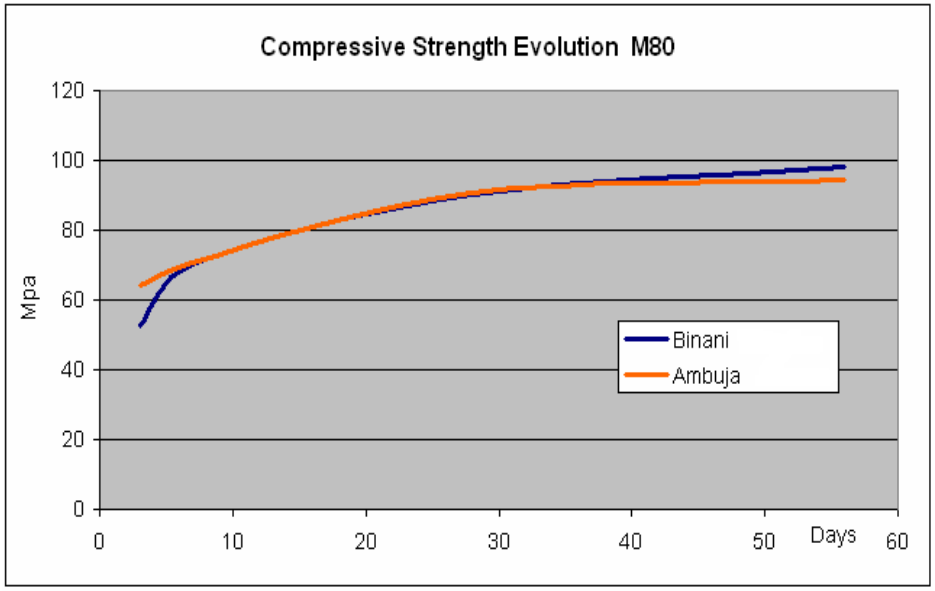




These properties are strongly impacted by the type of chemicals admixtures , today mostly PCE or blend of different types of PCE / or PP

Mechanical strength

- Mechanical strength depends on
  - Aggregates strengths
  - Paste strength
    - quantity of voids (bubbles and porosity)
    - quality of the hydrates and their cohesion)
  - Quality of the paste/aggregate interface
  - (“ interfacial transition zone”: ITZ)
  - Packing density of the entire granular skeleton (from aggregates to ultra-fines)



High performances concrete

WORLD ONE PROJECT - Lower Parel – MUMBAI

- **Over 120 stories, 1500 feet**
- **Architects Pei Cobb Freed & Partners**
- **Structural consultants LERA**

- **250,000 cubic meters of concrete**
- **35,000 metric tons of steel rebar**
- **40,000 sq m of glass**
- **14 million man hours.**
- **18 elevators travelling at upto 8 metres/sec**

Rs. 2,000 crores

(USD 440 million)

High performances concrete

WORLD ONE PROJECT - Lower Parel – MUMBAI

RAFT FONDATION ON PILES (close to 5 meter)

10 000 M3 of M40 SCC GGBS + OPC
5000 M3 of M60 SCC GGBS + OPC

Constraints from specifications / execution

Max core temperature = 72 deg

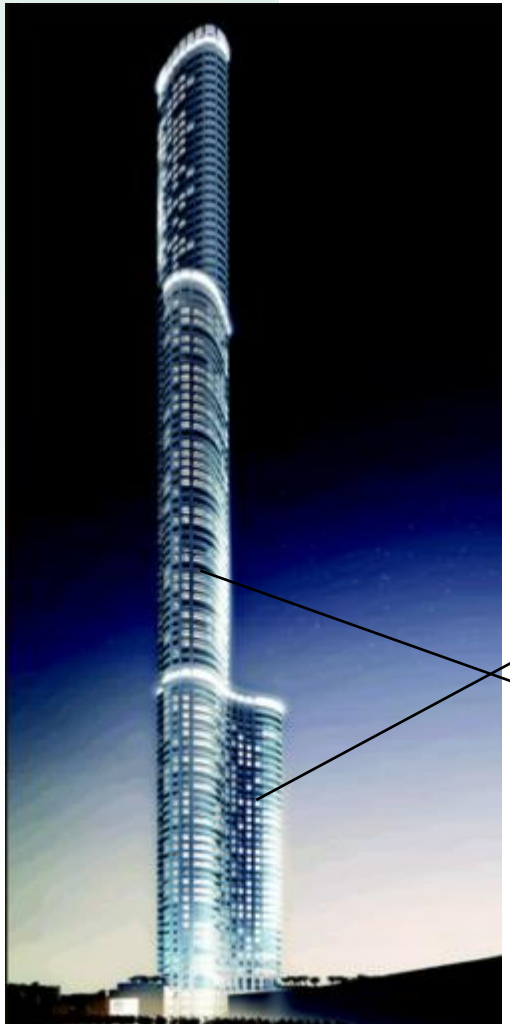
Self compacting

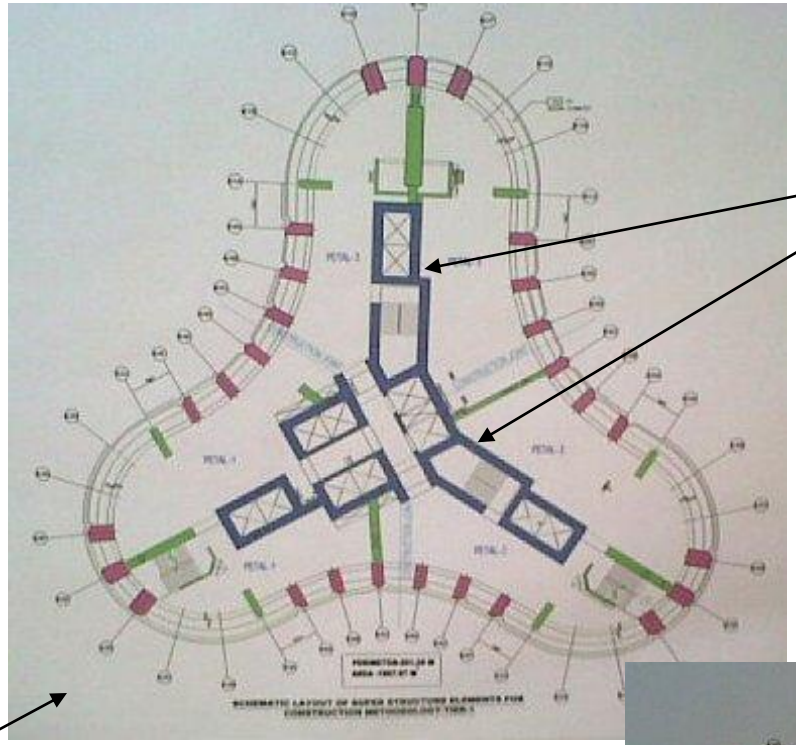
Durability

High performances concrete

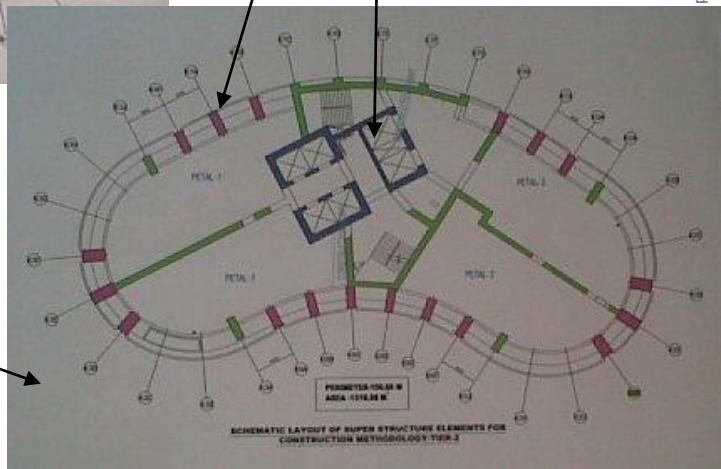
WORLD ONE PROJECT - Lower Parel – MUMBAI

Structures





Core wall
Columns
M95 / C80



High performances concrete

WORLD ONE PROJECT - Lower Parel – MUMBAI

Columns
M95 / C80

High performances concrete

WORLD ONE PROJECT - Lower Parel – MUMBAI

Core wall
Columns
M95 / C80

High performances concrete

WORLD ONE PROJECT - Lower Parel – MUMBAI

High performances concrete

WORLD ONE PROJECT - Lower Parel – MUMBAI

Fresh Performances of the M95/C80

Very close to self compacting performance but high viscosity

Slump retention > 2.5 hours

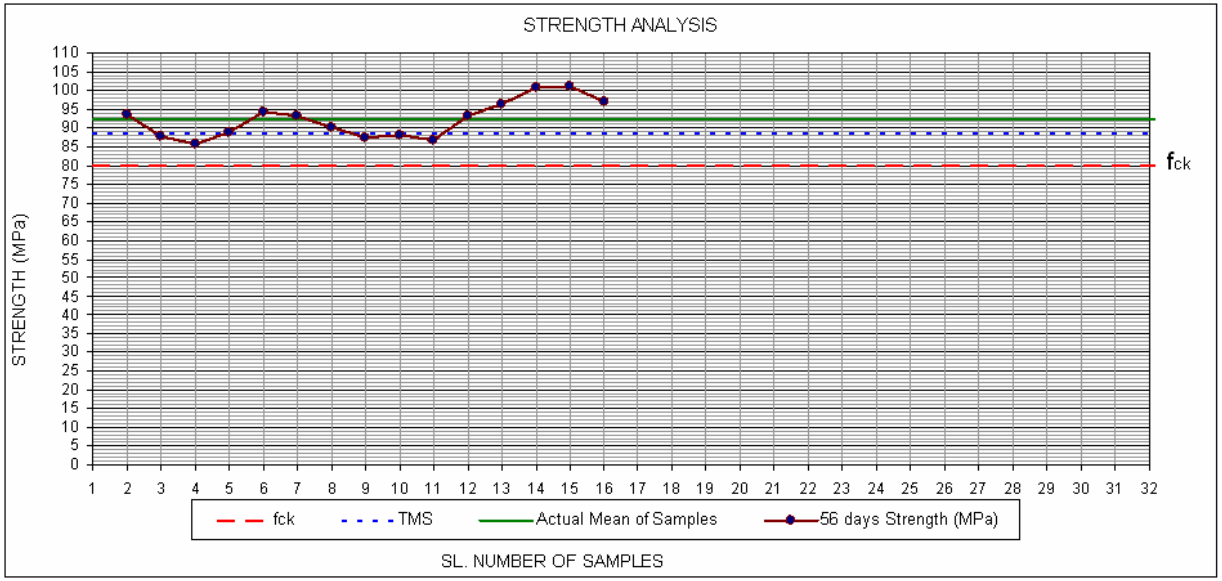
Pumpability

Segregation index below 5% (EFNARC)

High performances concrete

WORLD ONE PROJECT - Lower Parel – MUMBAI

Performances of the M95/C80



OBSERVATIONS FROM STATISTICAL ANALYSIS

f_{ck}	80	Mean	92.3	Estbd. Std. Dev.	4.9
Probability of getting less strength than 80 MPa =					0.657%
Calculated Proportion of low results =					1 in 152
Calculated Value of Statistical Constant (t) =					2.48

Assumed Standard Deviation =	5.0
Accepted Proportion of low results =	1 in 20
Statistical Constant (t) taken for Calculation =	1.65

HIGH PERFORMANCES

CONCRETE

Jean-Michel Laye Head QC – Product Development Lafarge India