Performance of SCC Made with Limestone Fillers

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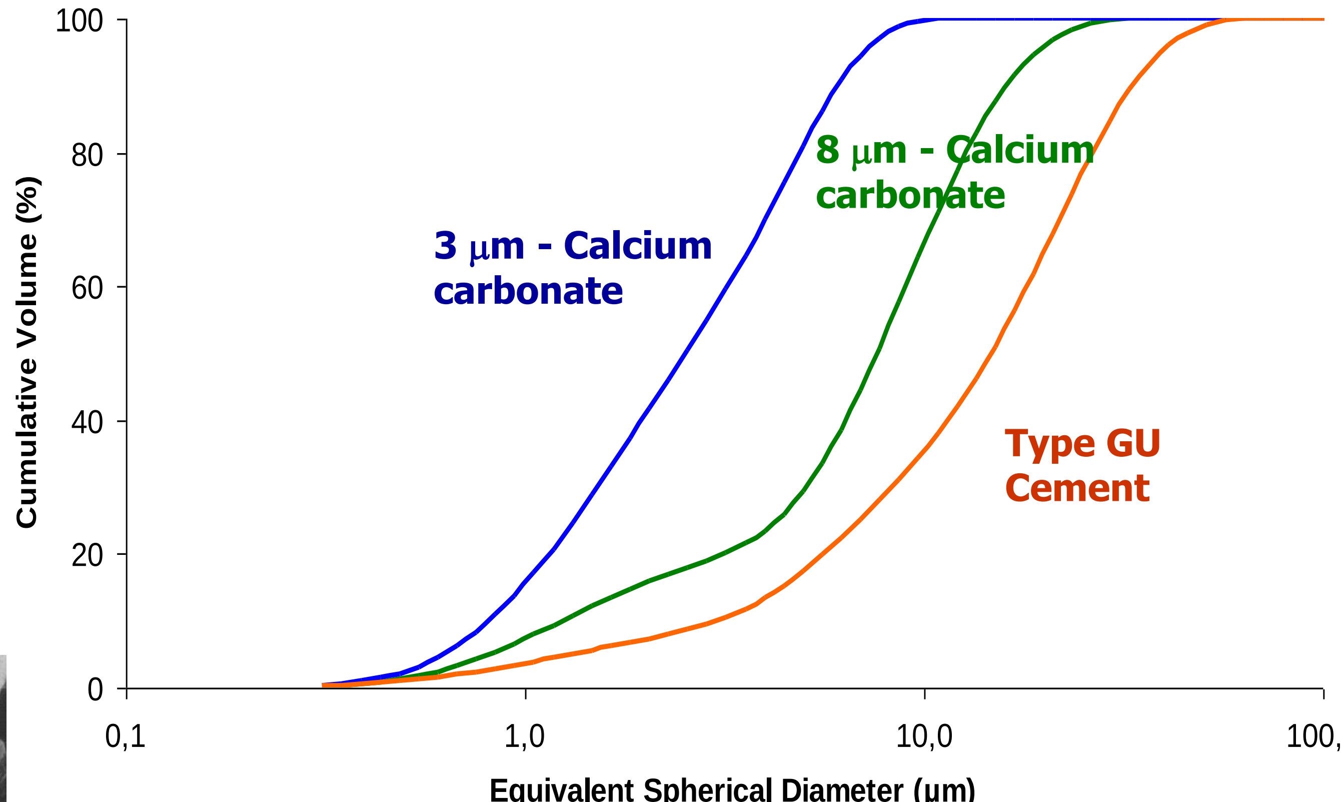
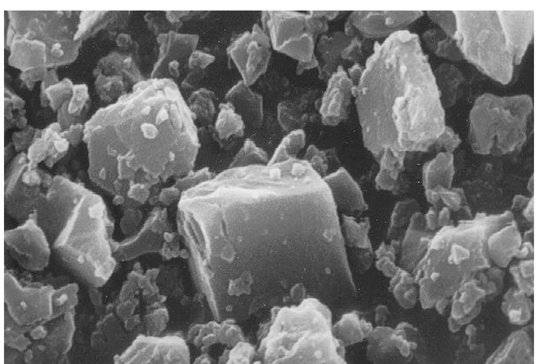
Bonneau, O., Tchieme, F., Khayat, K.H., Kanduth, B., *Use of Manufactured Calcium Carbonate in SCC Targeted for Commercial Applications*, Proc. 5th Int. RILEM Symp. on SCC, Vol. 3, Ghent, Belgium, Ed. G. De Schutter, V. Boel, Sept. 2007, 1105-1112.

MISSOURI S&T

Manufactured Calcium Carbonate

BETOCARB by OMYA

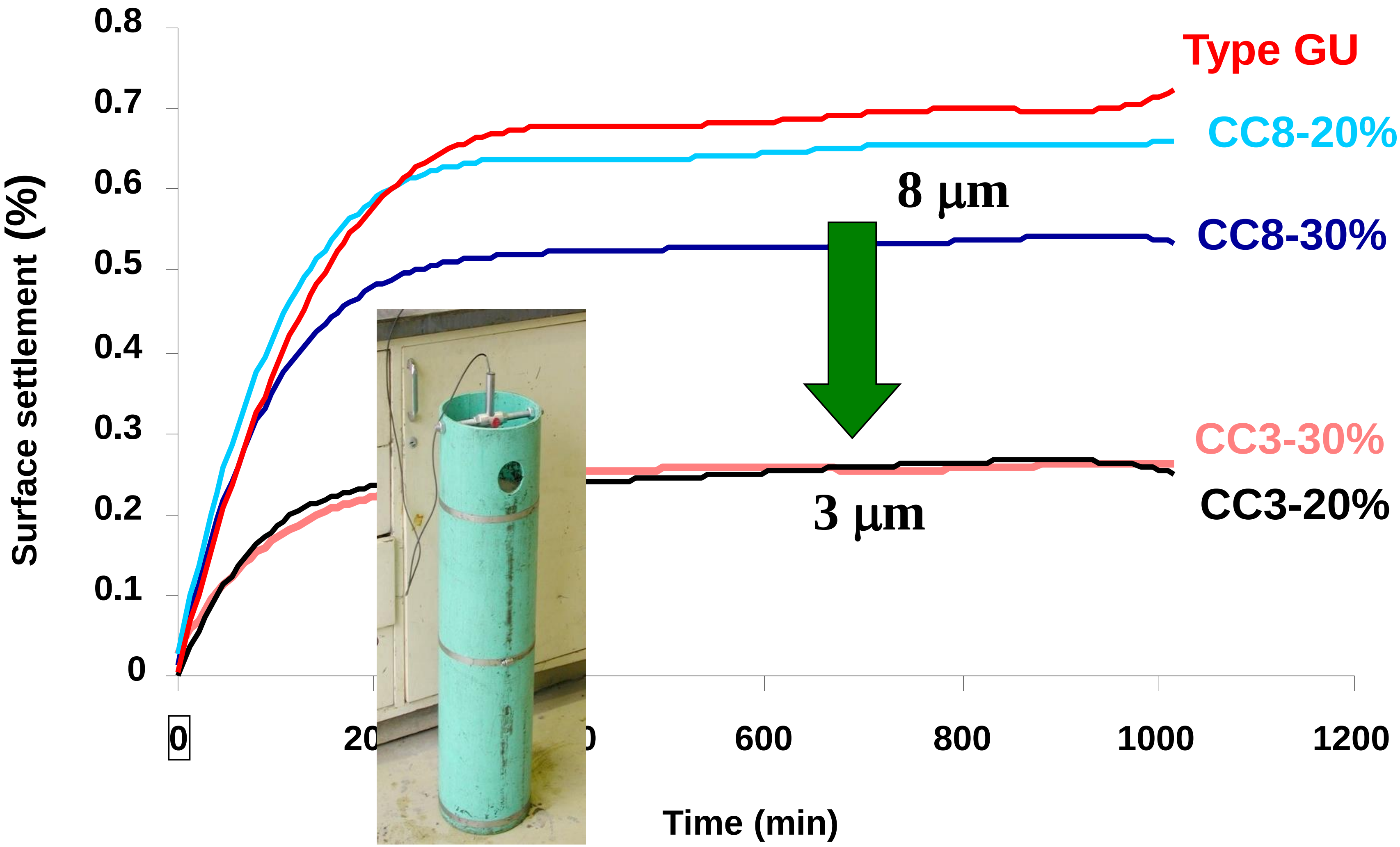




Calcium Carbonate	95%
Magnesium Carbonate	2%

Selection of Calcium Carbonate

Cast-in place SCC w/p = 0.42



Objective

Investigate performance of manufactured calcium carbonate (CC3) in air-entrained SCC:

- **Cast-in-place SCC for commercial applications**
  - **28-d f'c ≥ 32 MPa**
- **Precast-prestressed structural applications**
  - **28-d f'c ≥ 55 MPa, ≥ 30 MPa after 18 h of steam curing**
- **Precast architectural applications**
  - **28-d f'c ≥ 35 MPa, ≥ 15 MPa after 18 h of steam curing**

Calcium carbonate D_{50}=3 µm (CC3)

SCC	Binder (kg/m³)	w/p	Polysac-caride VEA (mL/m³)	PC-based HRWRA Targeted slump flow	AEA Targeted air volume
Cast-in-place, Commercial Type GU cement 0, 10, 15, 20% CC3	425	0.42	750	630 mm	6%-9%
Precast, prestressed Type III cement 0, 10, 15, 20% CC3	460	0.35	0	650 mm	6%-9%
Precast, architectural Type I/II cement 0, 10, 15, 20% CC3	480	0.38	580	650 mm	6%-9%

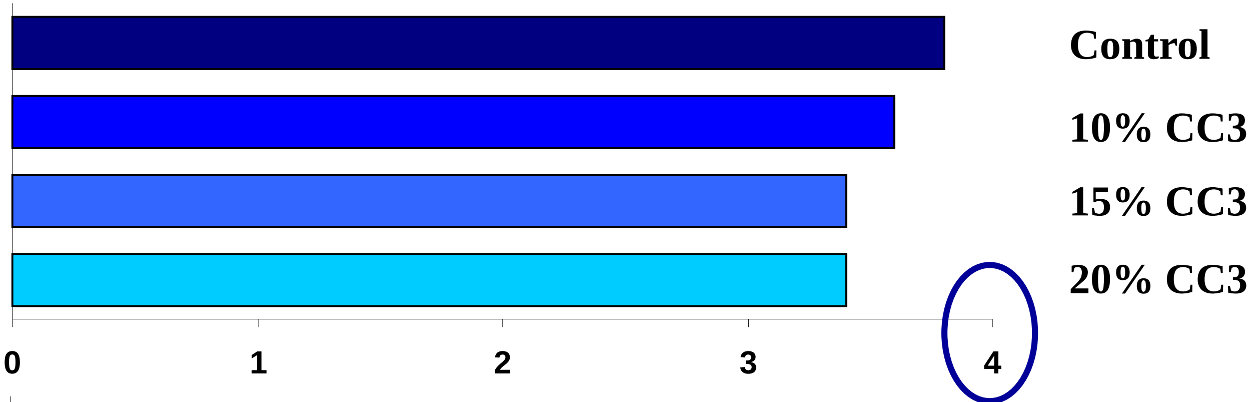
Testing Program

Cast-in-place and precast SCC

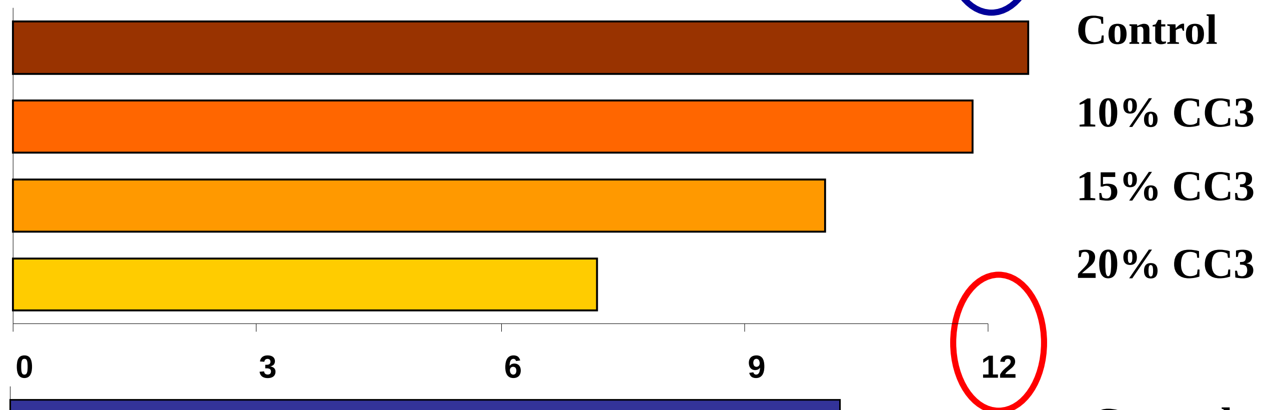
Fresh state	Slump flow Air volume Filling capacity L-box J-ring	V-funnel flow (65x75 mm) Rheometer Surface settlement Segregation index Temperature rise
Mechanical properties	Compressive strength @ 1, 7, 28 d Flexural strength @ 28 d Elastic modulus and Poisson's ratio @ 28 d	
Shrinkage	Drying Shrinkage after 7 d of water curing	
Durability	Frost resistance (ASTM C666 Proc. A) Air-void system (ASTM C457) Scaling resistance (ASTM C672) Rapid chloride-ion penetration (ASTM C1202)	

HRWRA demand (L/m^3)

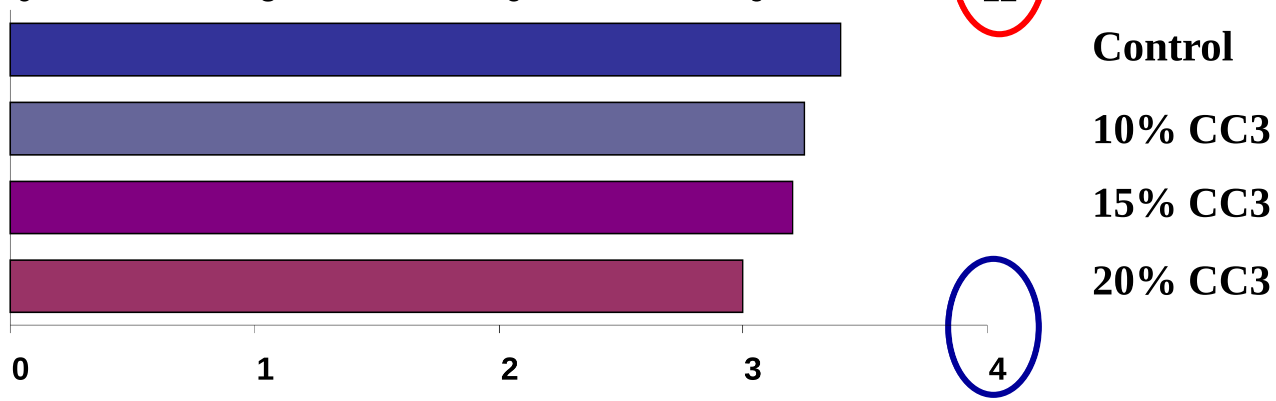
Cast-in-place
Commercial
w/p = 0.42



Precast
Prestressed
w/p = 0.35

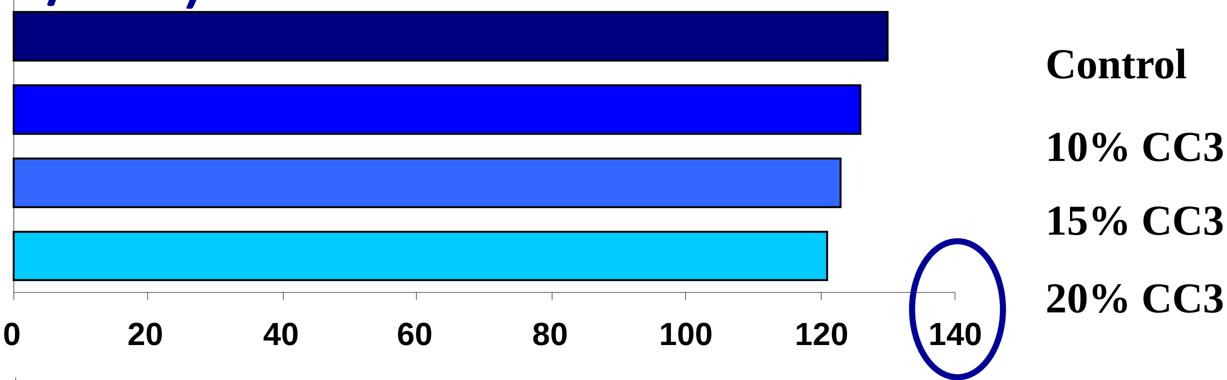


Precast
Architectural
w/p = 0.38

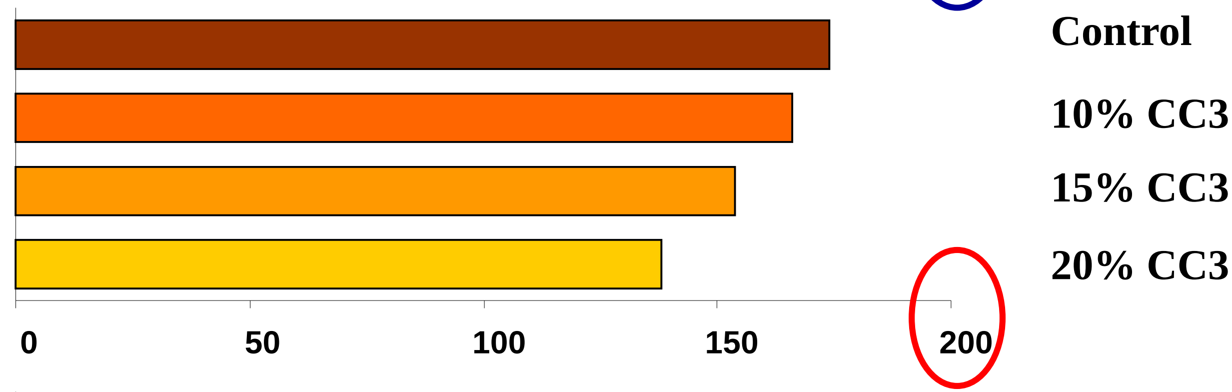


Unit Cost ($C/m³)

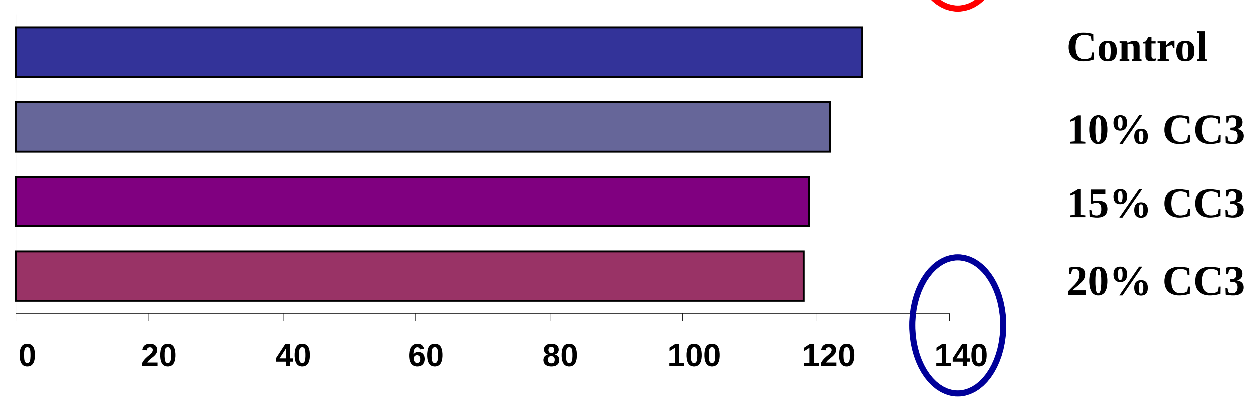
Cast-in-place Commercial



Precast Prestressed

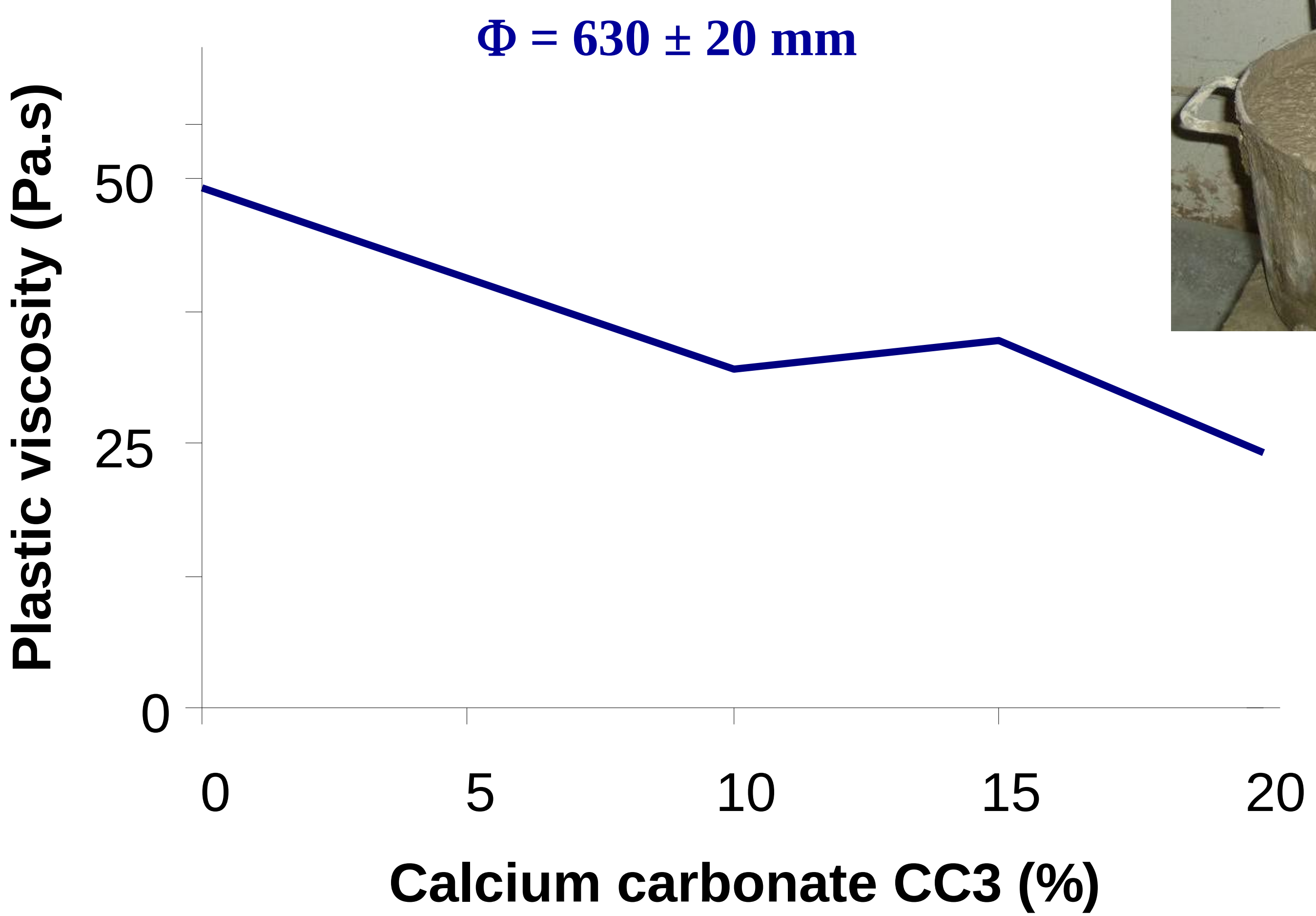


Precast Architectural



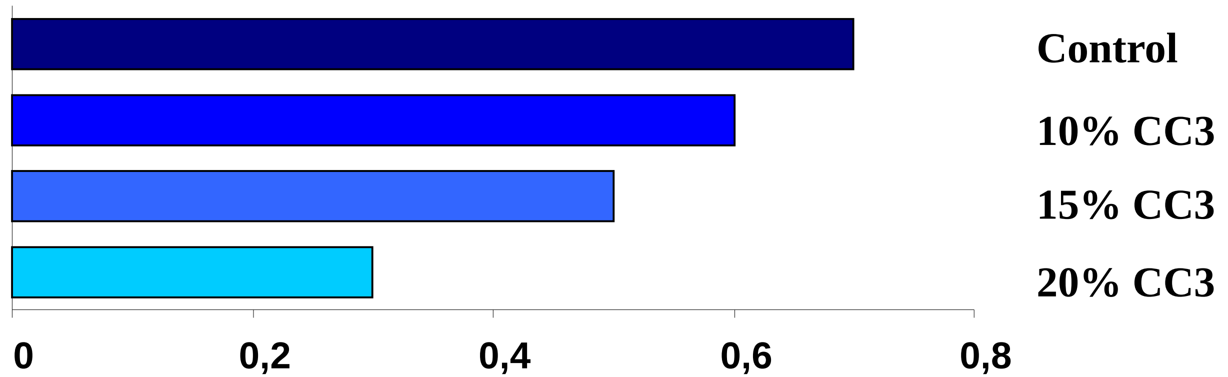
Rheology

Cast in-place commercial applications

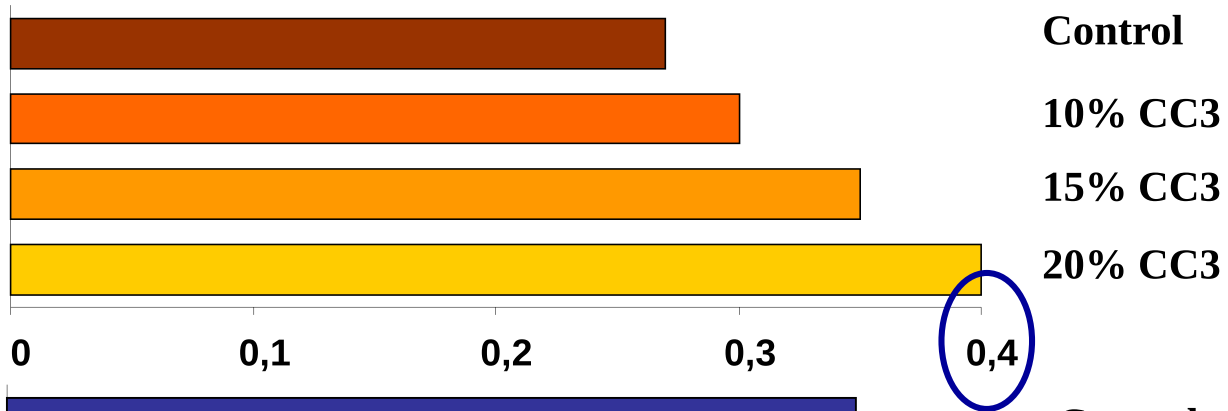


Surface settlement (%)

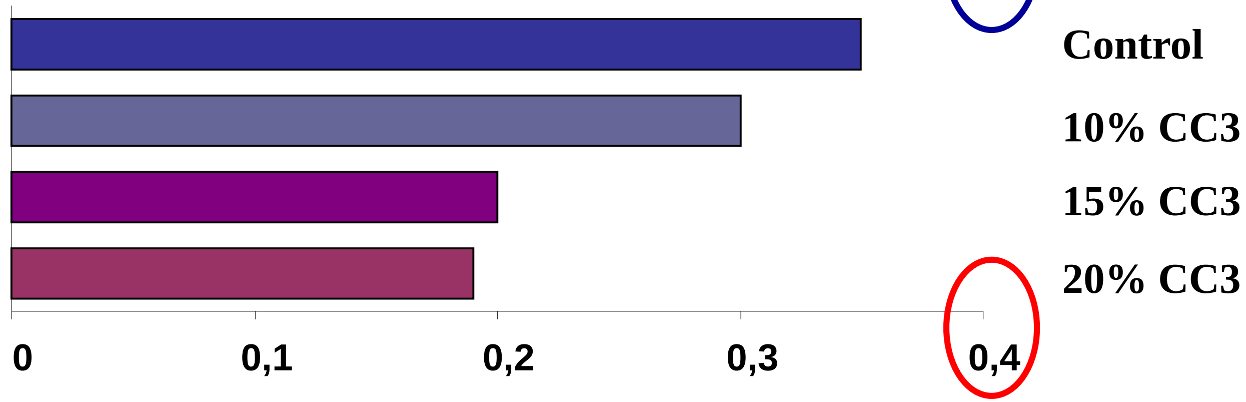
Cast-in-place Commercial



Precast Prestressed



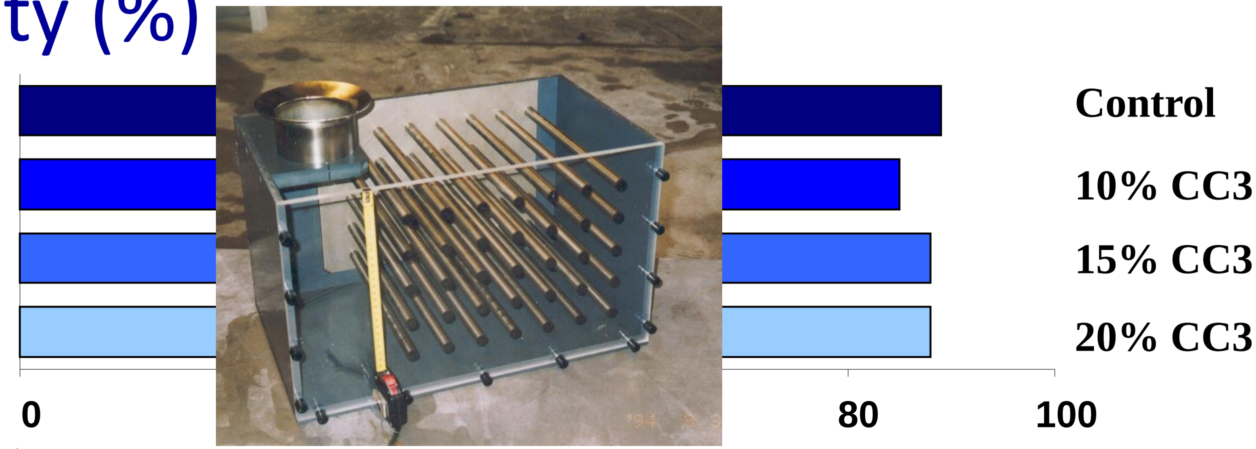
Precast Architectural



Filling capacity (%)

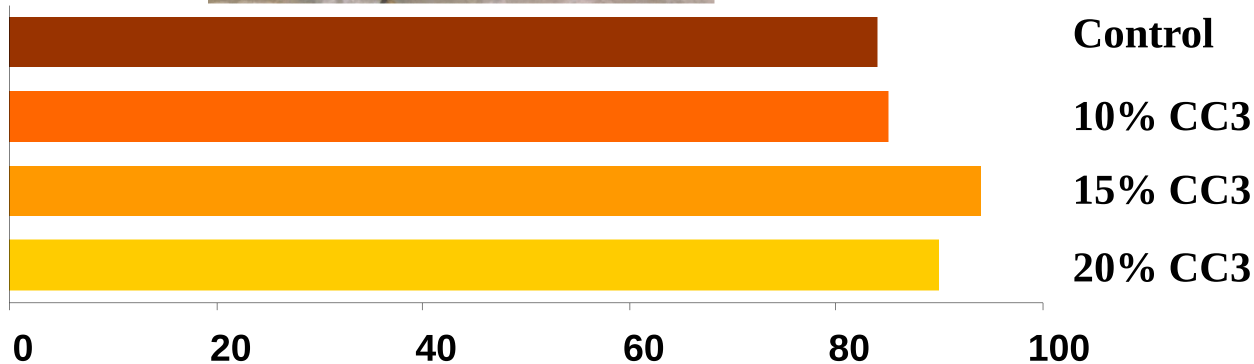
Cast-in-place

Commercial



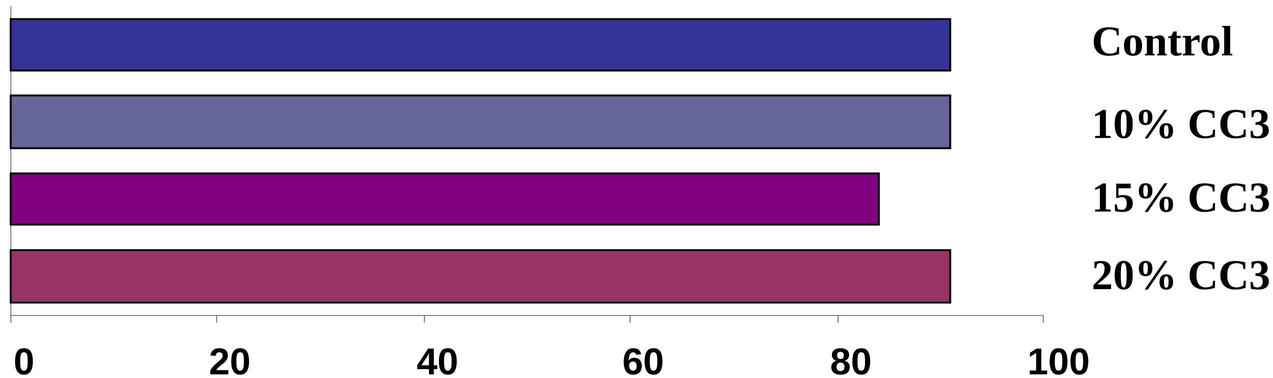
Precast

Prestressed

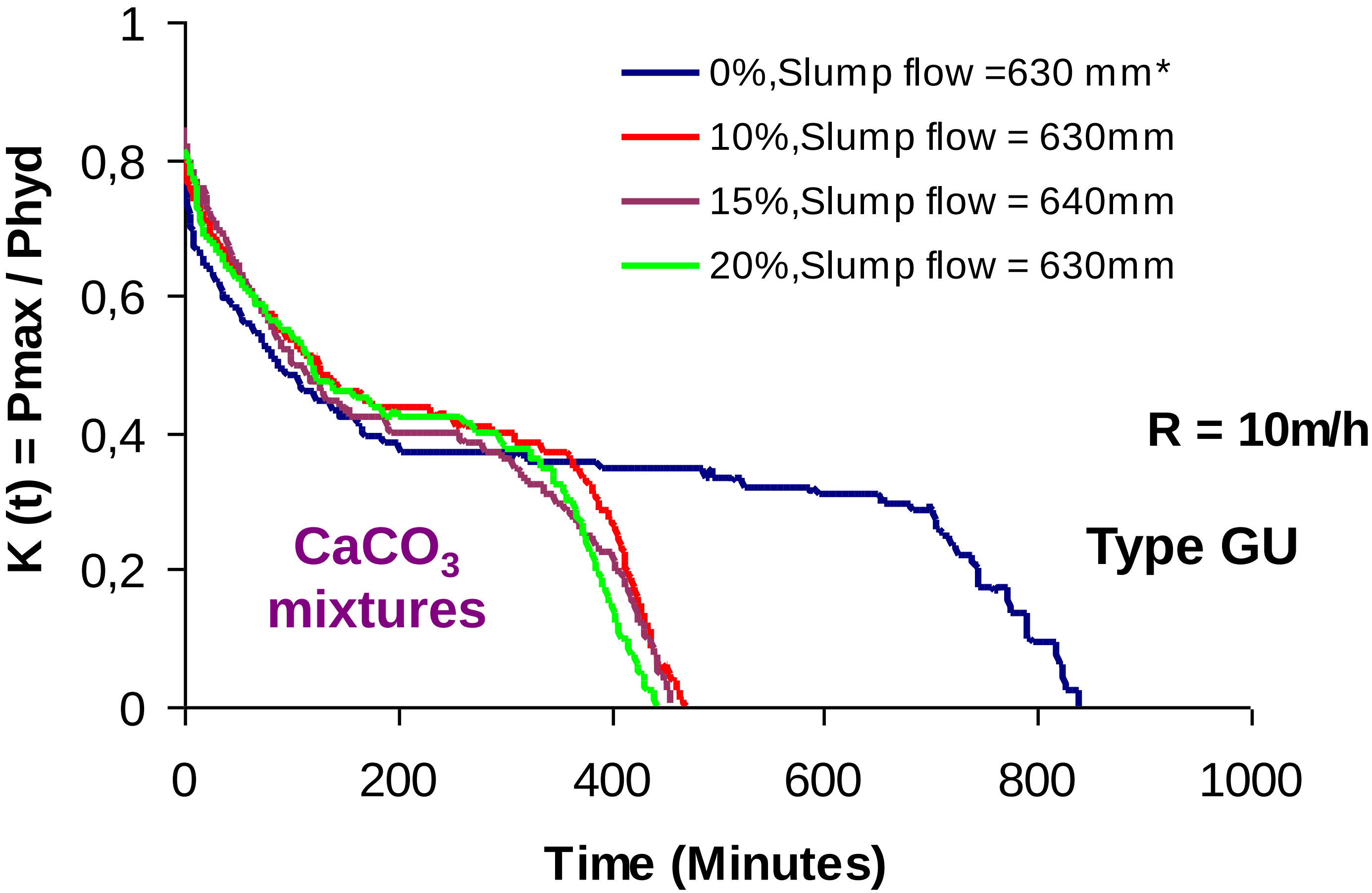


Precast

Architectural



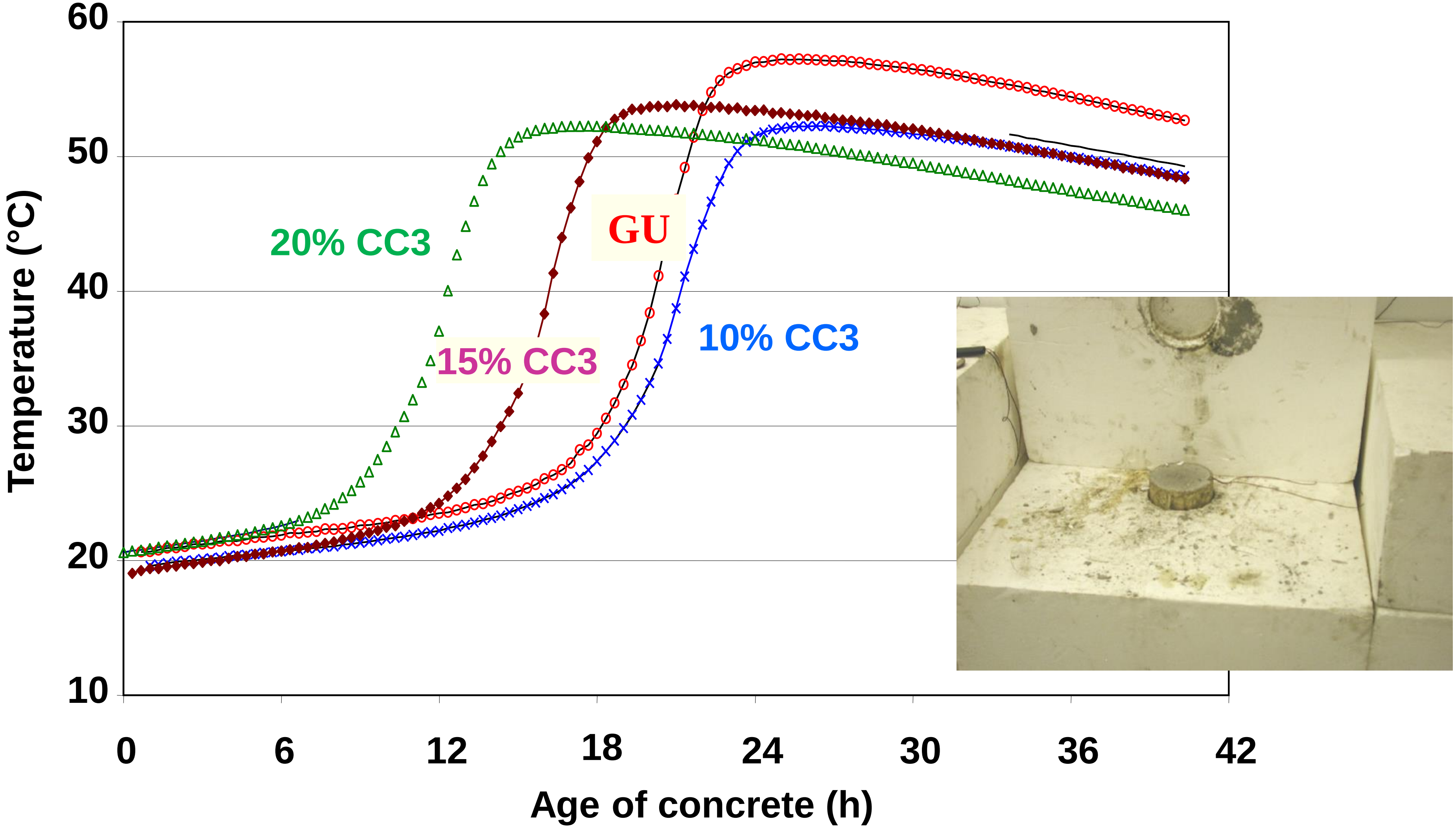
Form Pressure - Cast-in-place commercial SCC



Acceleration of C_3S hydration : initial reaction of CC with aluminate phase of cement to form calcium aluminate monocarbonate

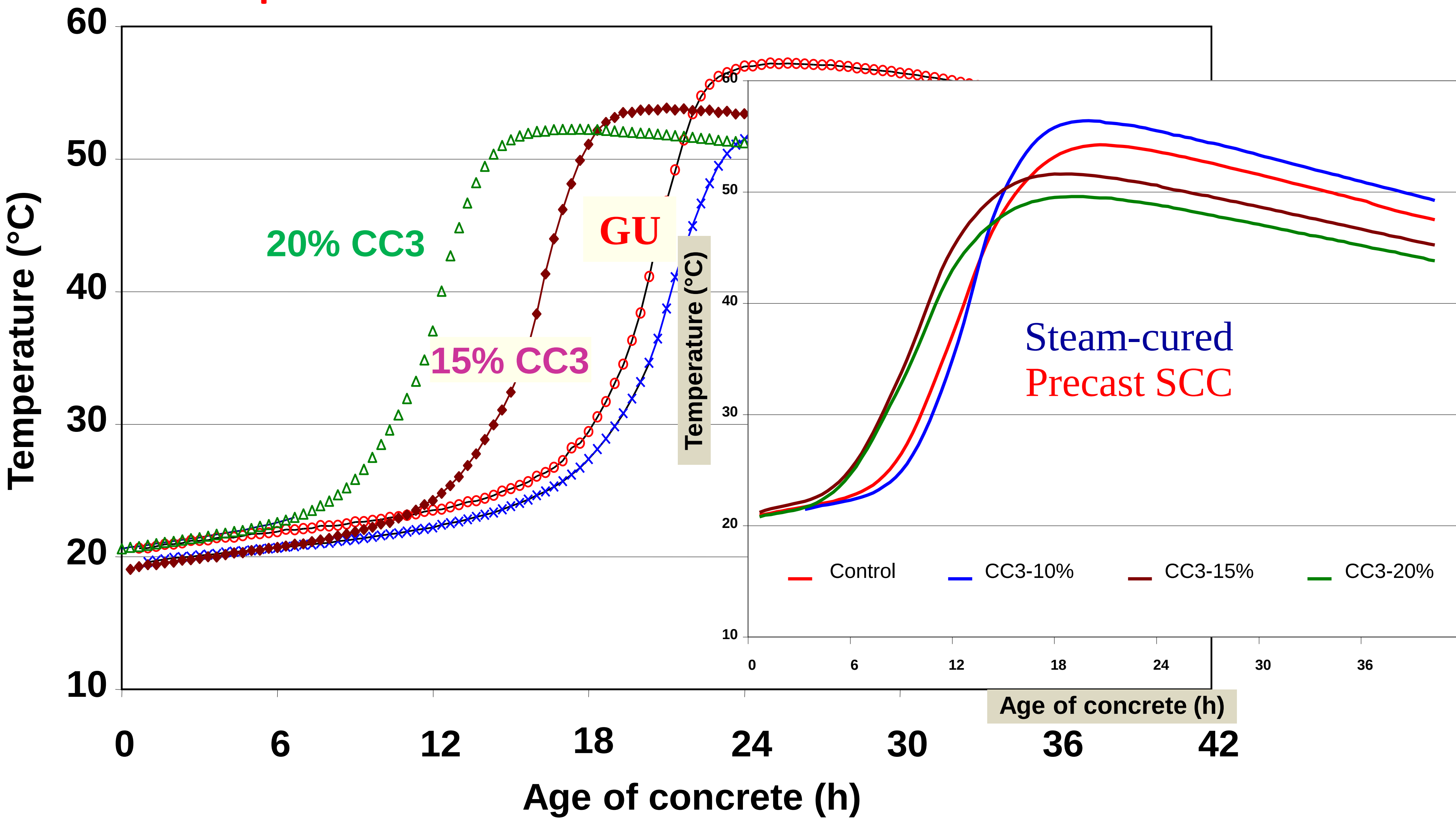
Semi-adiabatic temperature rise

Cast-in-place commercial SCC



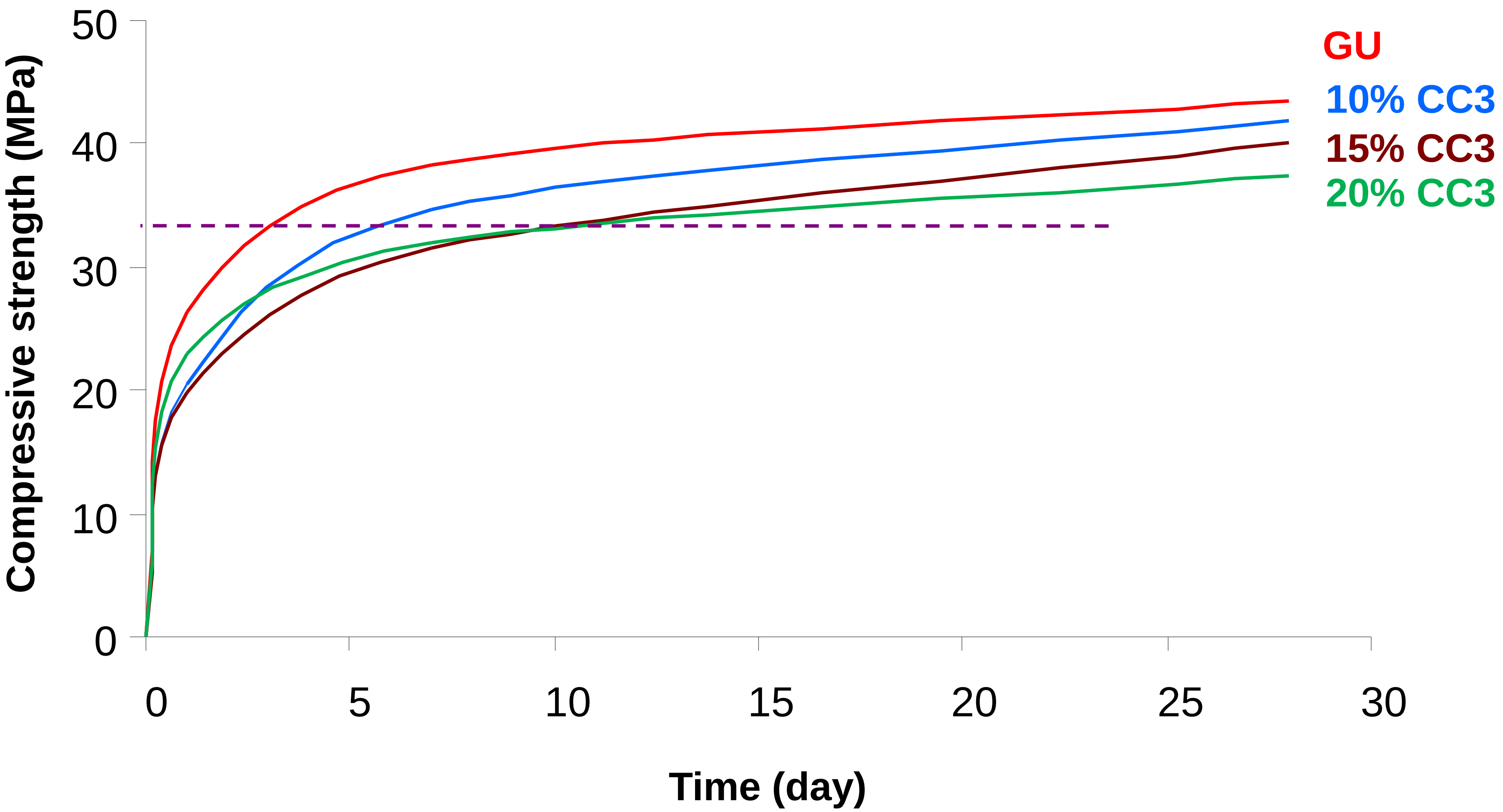
Semi-adiabatic temperature rise

Cast-in-place commercial SCC



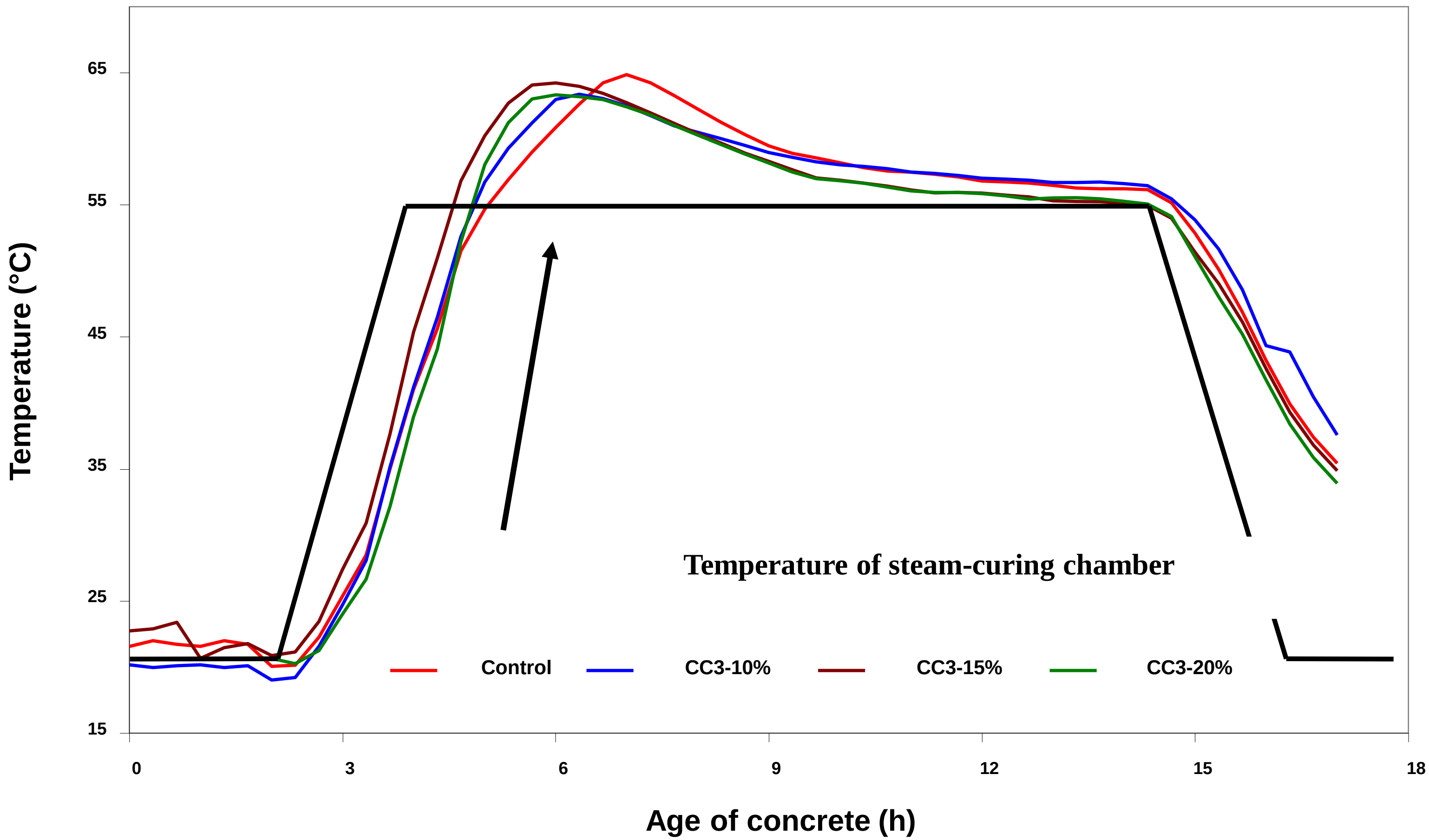
Compressive Strength

Moist curing - Cast-in-place SCC



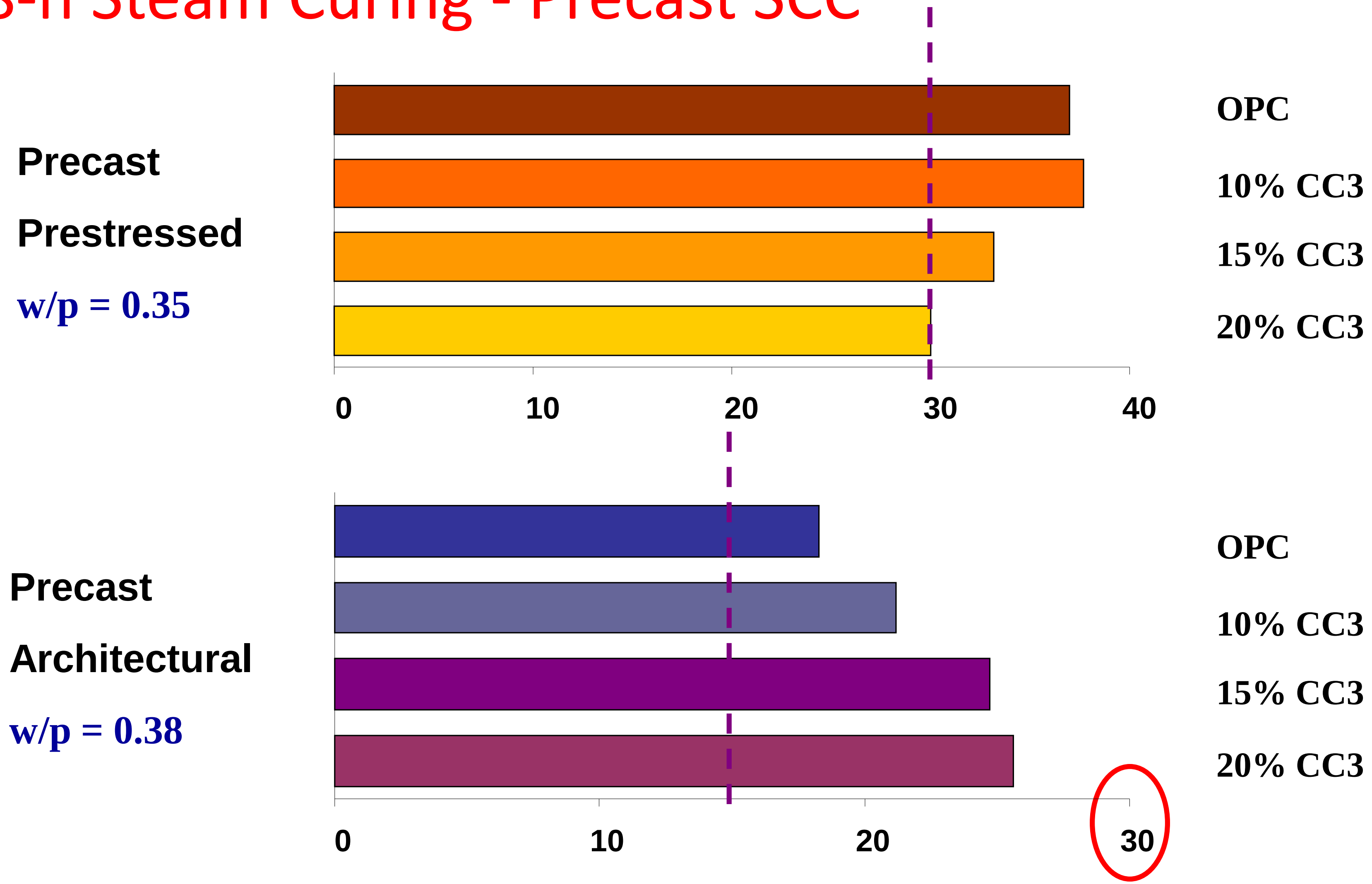
Steam Curing

Precast prestressed



Compressive Strength (MPa)

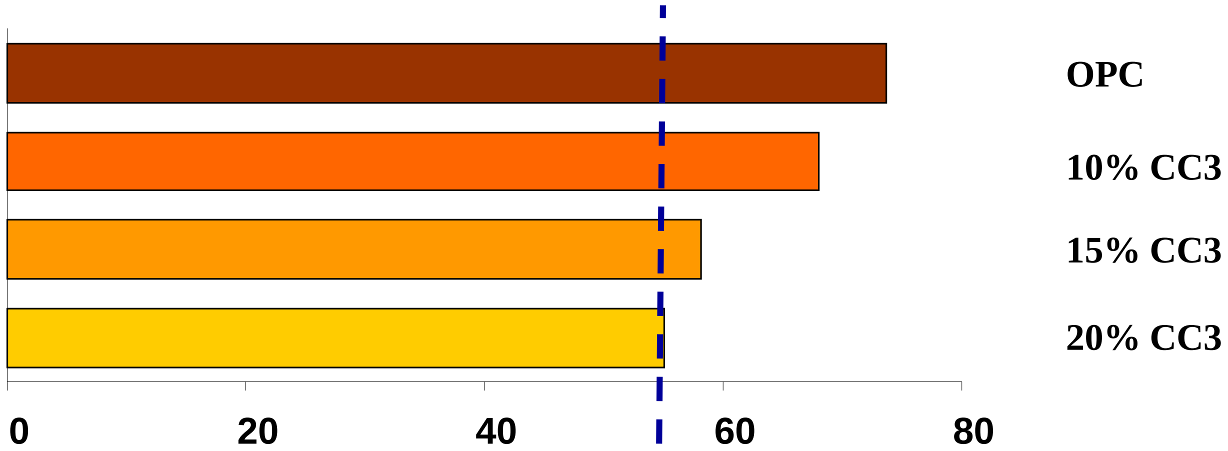
18-h Steam Curing - Precast SCC



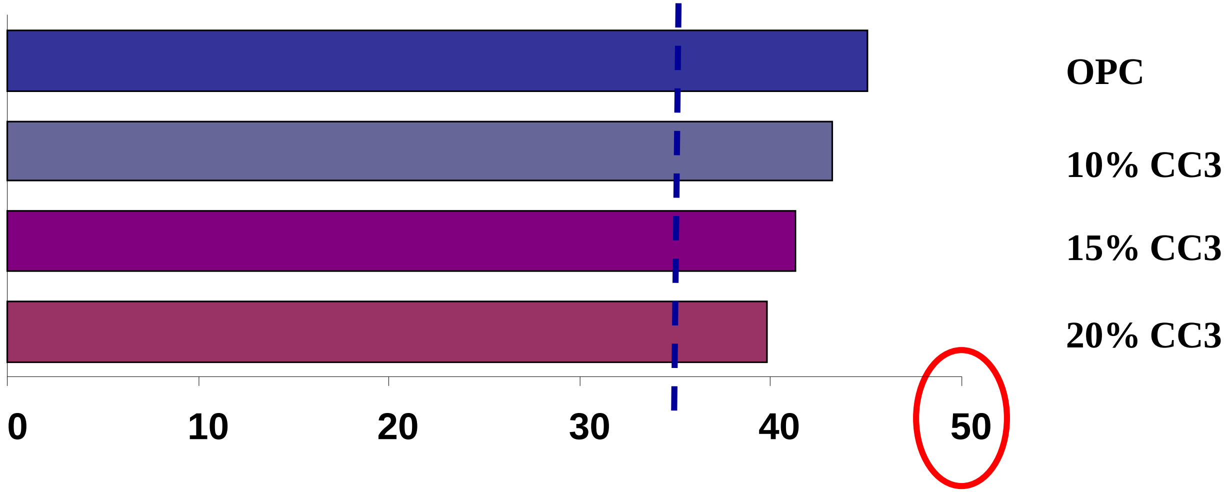
Compressive Strength (MPa)

Moist curing @ 28 d - Precast SCC

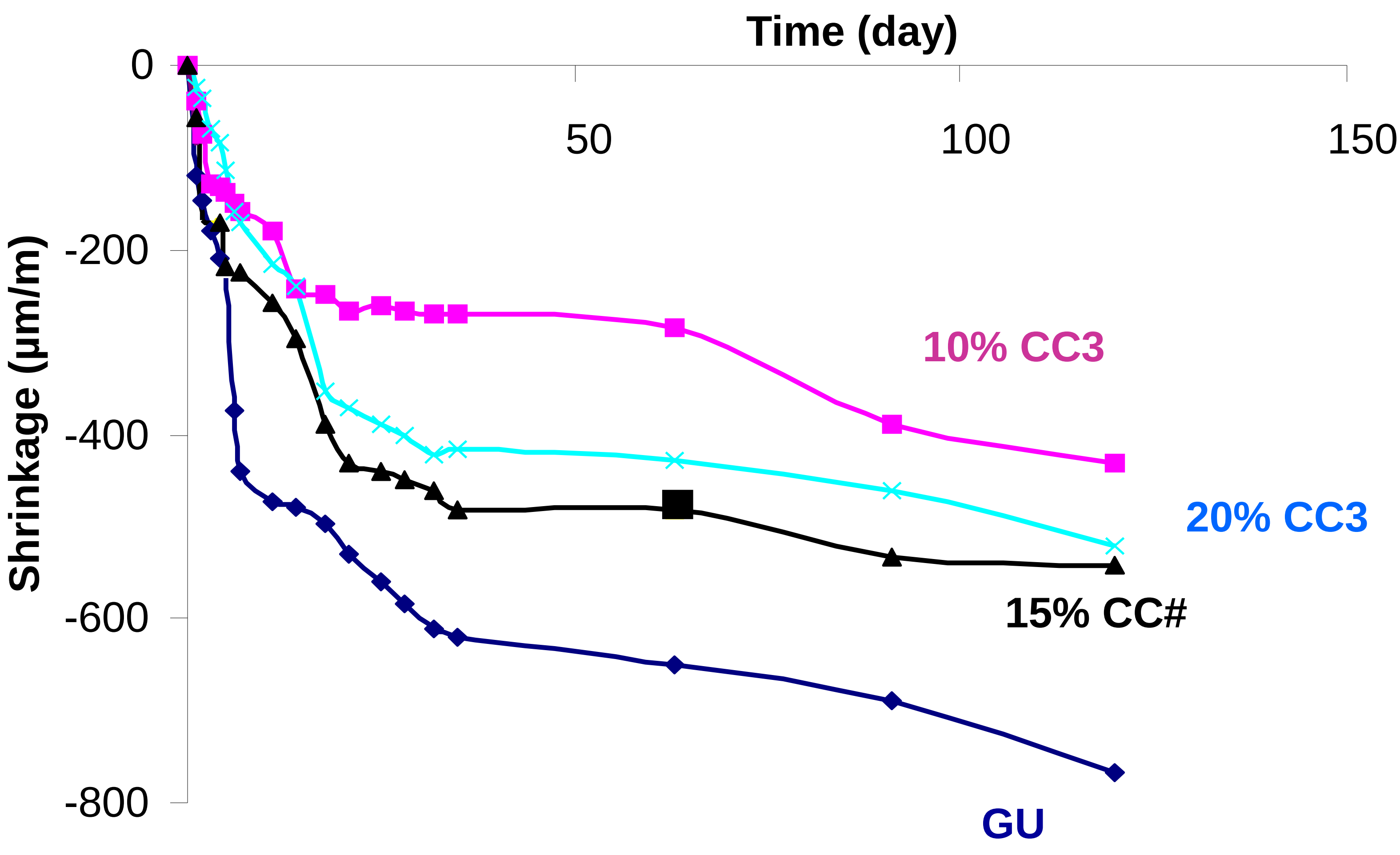
Precast Prestressed



Precast Architectural



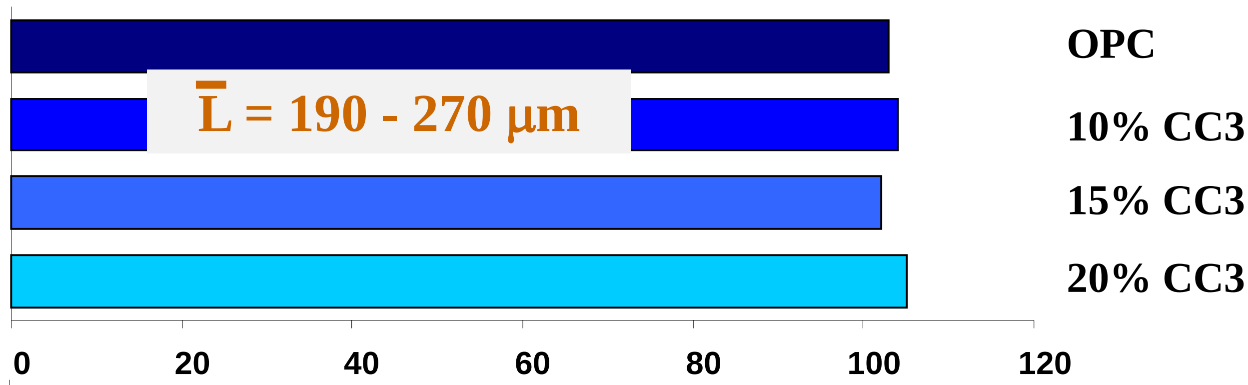
Drying shrinkage
Precast architectural SCC



Freeze-thaw durability factor (%)

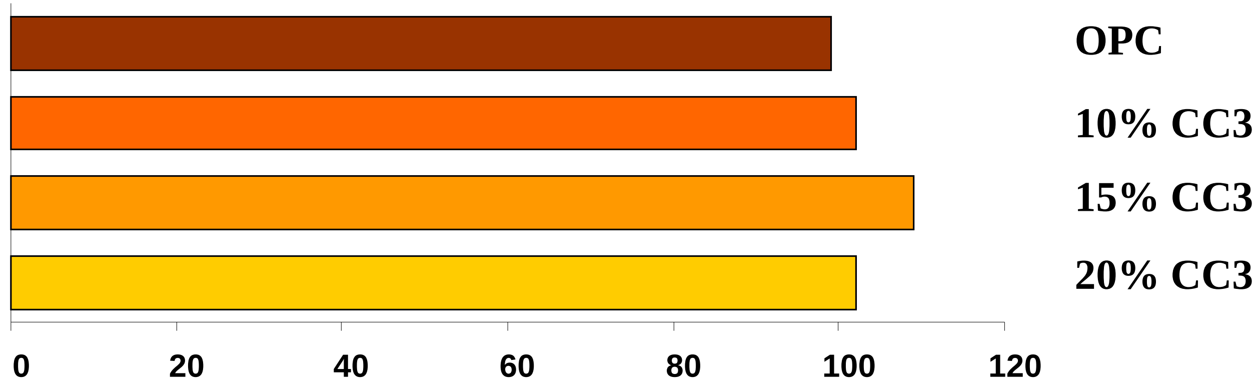
Cast-in-place

Commercial



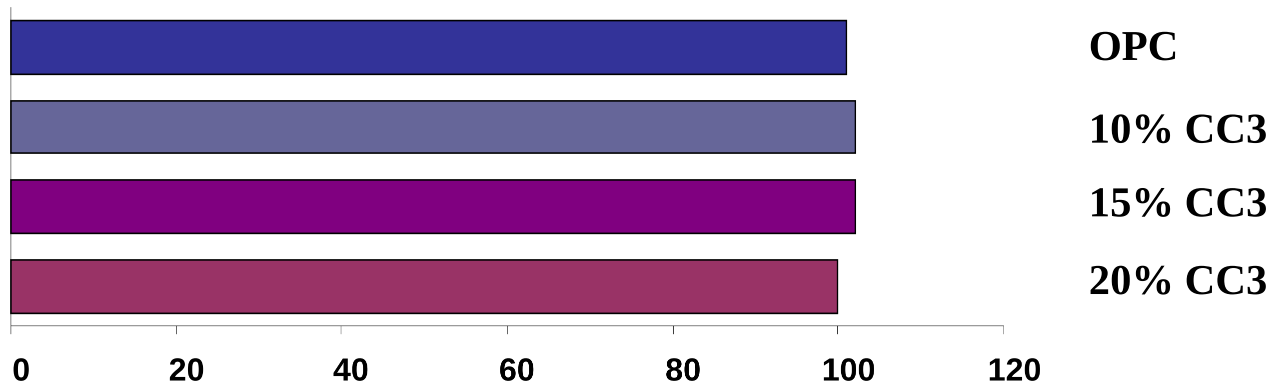
Precast

Prestressed

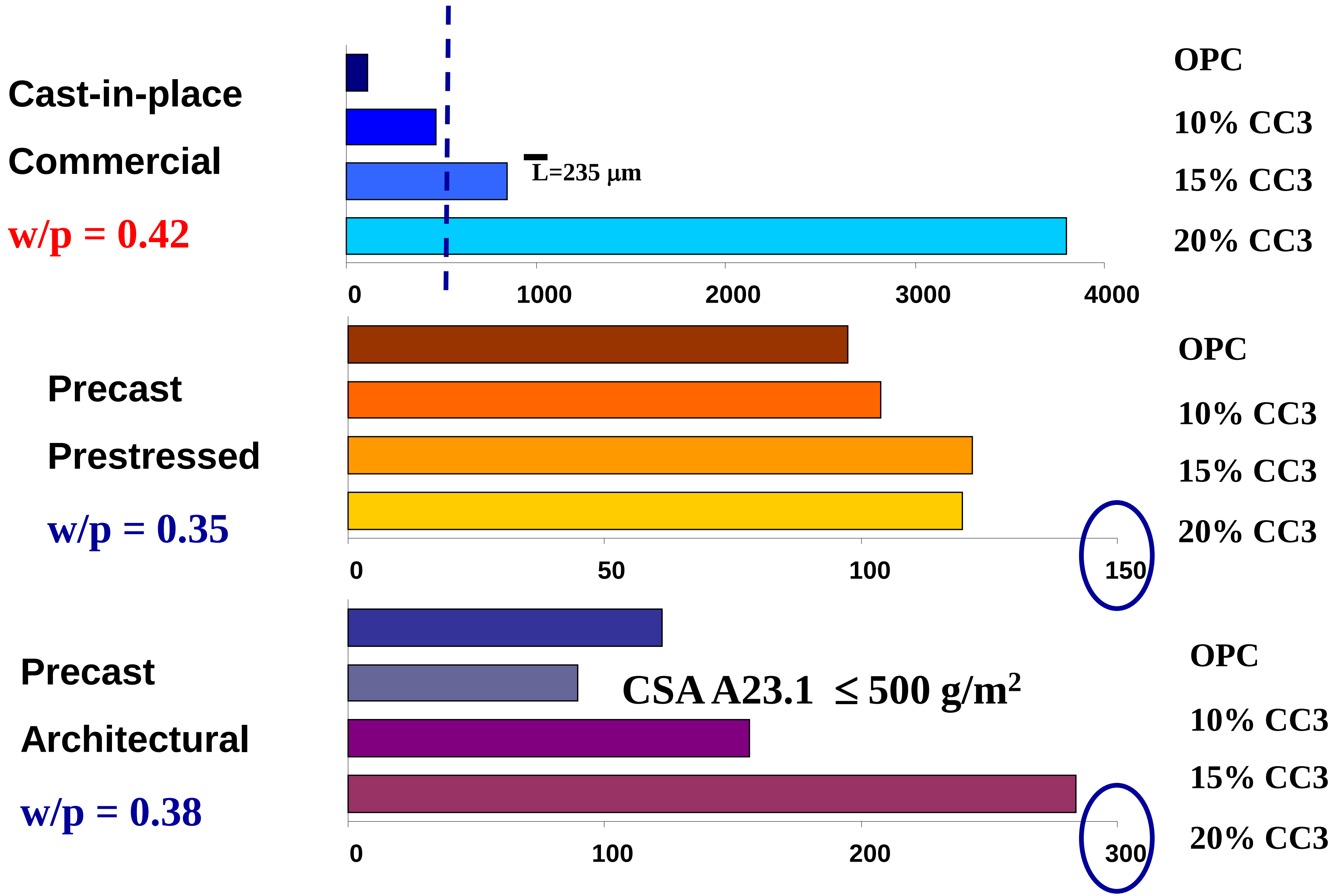


Precast

Architectural



Scaling resistance (g/m²)



For 10% - 15% cement replacement with Betocarb3

- **Increase in packing density**
  - **Significant increase in static stability (cast-in-place and precast architectural SCC)**
  - **~ 10% - 20% reduction in unit cost**
- **Acceleration of C_3S hydration**
  - **Faster cancellation of form pressure**
  - **Limited loss in compressive strength @ 1 d**
  - **≥ compressive strength after steam curing for precast SCC**
- **Adequate air-void system**
  - **High freezing and thawing resistance**
  - **Adequate scaling resistance for precast SCC and ≤ 10% for cast-in-place SCC**