Conferința Internațională
SOLUŢII PREFABRICATE DIN BETON

Thixotropy Control of Self Compacting Concrete with Dedicated Superplasticizers

INNOVATION IS OUR CHEMISTRY

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Authors: Philippe Ortega, Laurent Bonafous, Lucia Ferrari, Pascal Boustaingorry

Outline

- **Introduction**
- **Thixotropy of Self Compacting Concrete**
- **Thixotropy evaluation on a grout scale**
- **Thixotropy evaluation on a concrete scale**
  - In lab conditions
  - In industrial conditions
- **Conclusions**

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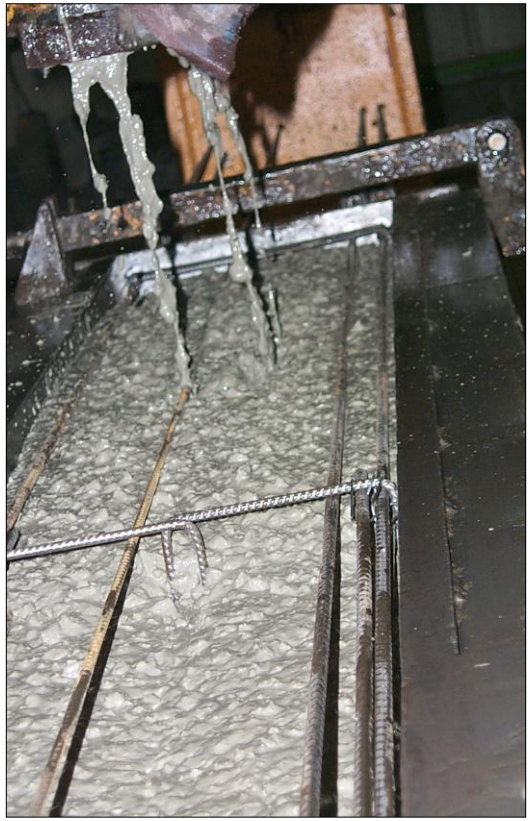
Introduction

Self Compacting Concrete, *a concrete with unique flowable properties*

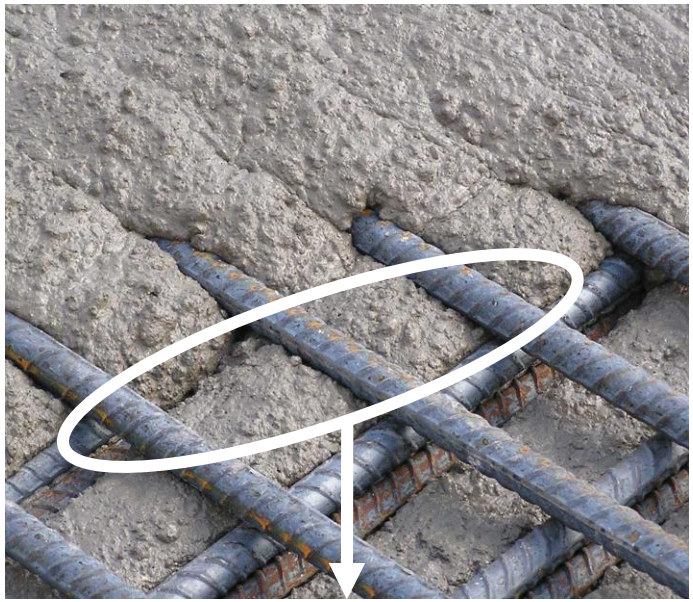


… with balanced viscosity

- A very high flow…

Introduction

But *in some cases, customers report a "wrong behaviour"…*



time-dependent reaction

"THIXOTROPY"

- Lack of free flow !
  - "sticky" or "heavy" concrete ;
  - Difficult to quantify with common tools

- **Mechanisms ?**
- **Superplasticizer impact ?**

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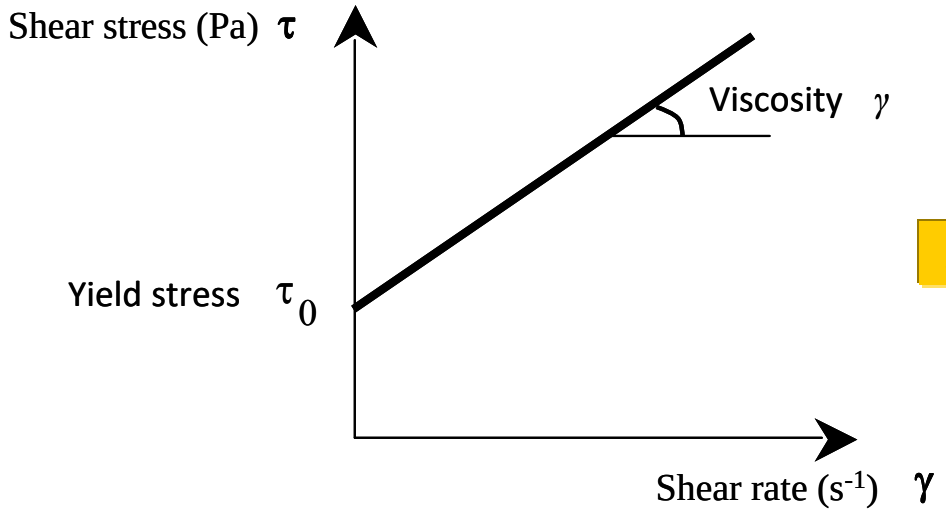
Thixotropy of Self Compacting Concrete

The Bingham rheological modelling

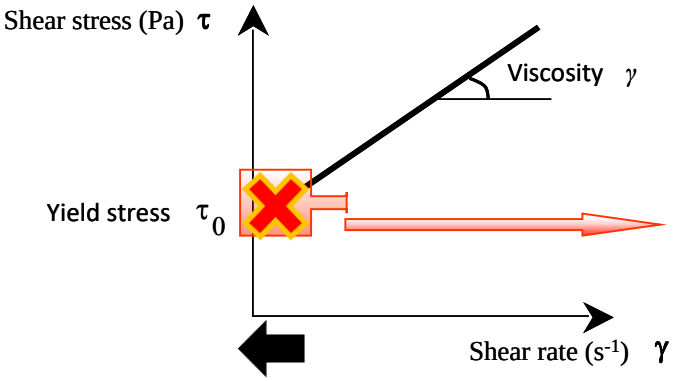


Bingham law : $\tau = \tau_0 + \mu\gamma$

- **Yield stress**: stress to apply in order to make concrete flow
- **Apparent viscosity**: ratio of the stress to the shear rate

Thixotropy of Self Compacting Concrete

At low shear rate, *concrete behaves differently…*



Flow at low shear rate:

non linear & **time dependent**

"THIXOTROPY"

- Viscosity and yield stress ↗ at low shear rate
  - ↪ **Gelification**
- Viscosity and yield stress ↘ when stress re-applied
  - ↪ **Fluidization**

Reversible phenomena !

Thixotropy of Self Compacting Concrete

Thixotropy *and its consequences on concrete properties during transient phases (pouring and casting steps) :*

- Shape stability (e.g. : shotcrete, slipforming) ;
- Less hydrostatic pressure on formwork ;
- Less risk of static segregation.

…but can affect:

- “self-placing” ability (e.g. long size elements) ;
- concrete pumping after restart ;
- Interface quality between pouring layers ;
- Surface finish quality.

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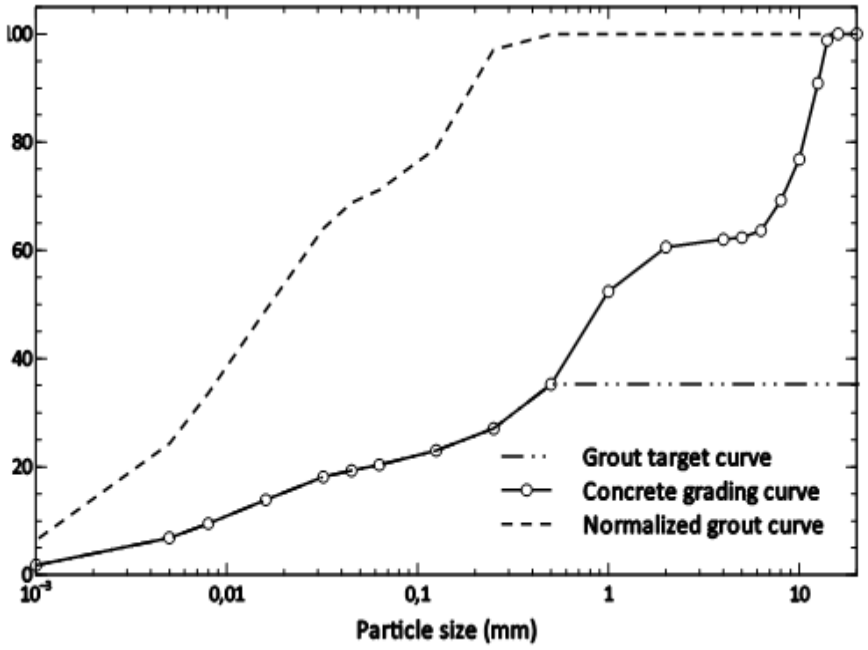
Thixotropy evaluation on grout scale

- ***Methodology :*** *inspired by Z. Toutou, N. Roussel, Multi scale experimental study of concrete rheology: from water scale to gravel scale, Materials and Structures. 39 (2006) 167–176.*
  - *rheological characteristics measured by rheometer and*
  - *mostly driven by the cement paste*

- Selecting an arbitrary size limit fitting the rheometer (e.g. 0.315 mm)

- Combining materials into a grout simulating the concrete grading curve at 0.315 mm maximum particle size



Thixotropy evaluation on grout scale

- ***Test protocol*** **:** *evaluation of 3 PCP based superplasticizers:*
  - *SP1 : common superplasticizer*
  - *SP2 & SP3 : designed for thixotropy reduction*

Composition for 400g dry content (g)	
Cement CEM I 52.5R	196.1
Limestone filler	89.6
0/0.160 mm sand	97.8
0/0.315 mm sand	20.7
Water	93.6

Superplasticizer dose adjusted for min-slump flow 105 ± 5 mm

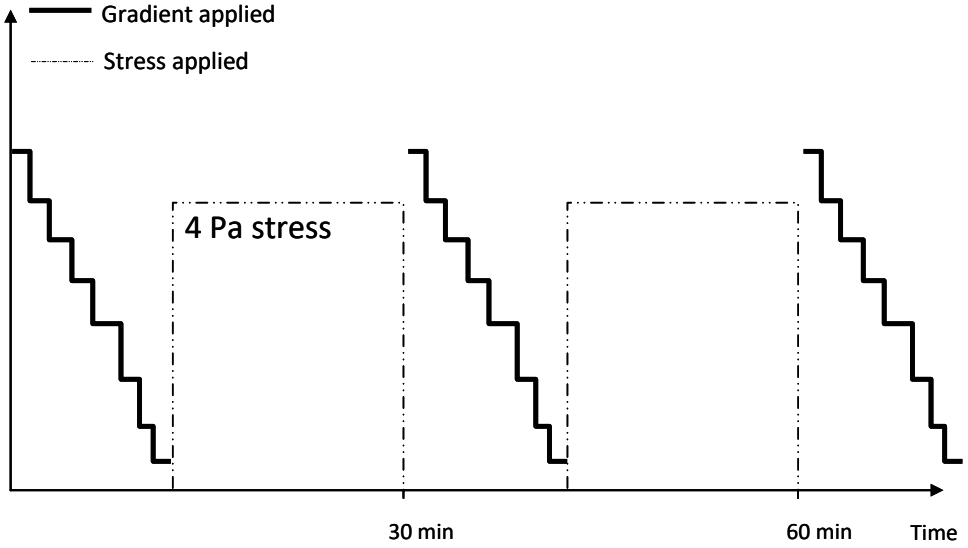
Thixotropy evaluation on grout scale

Test apparatus : *Kinexus rheometer (Malvern Instruments, UK)*

2 ways to evaluate thixotropy:

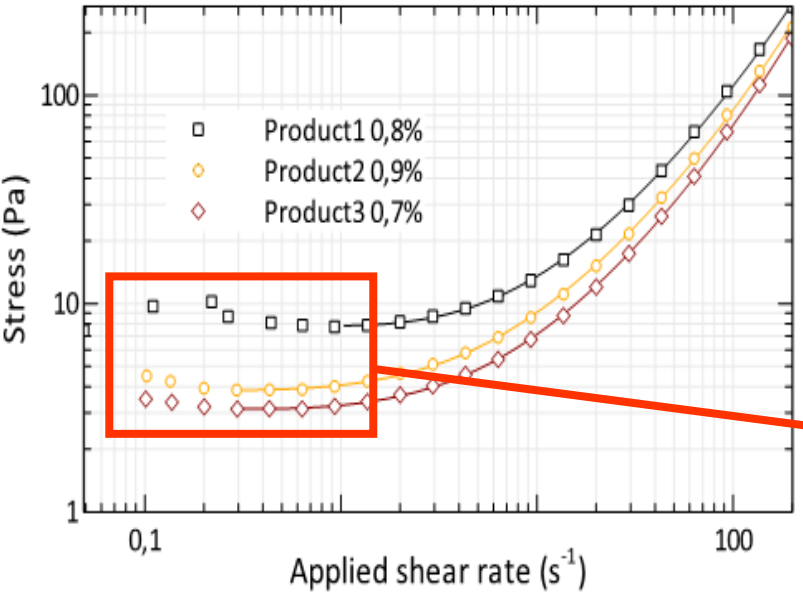
1 - **on shear stress** : logarithmic decreased increments from 200 to 0,01 s^{-1} ;

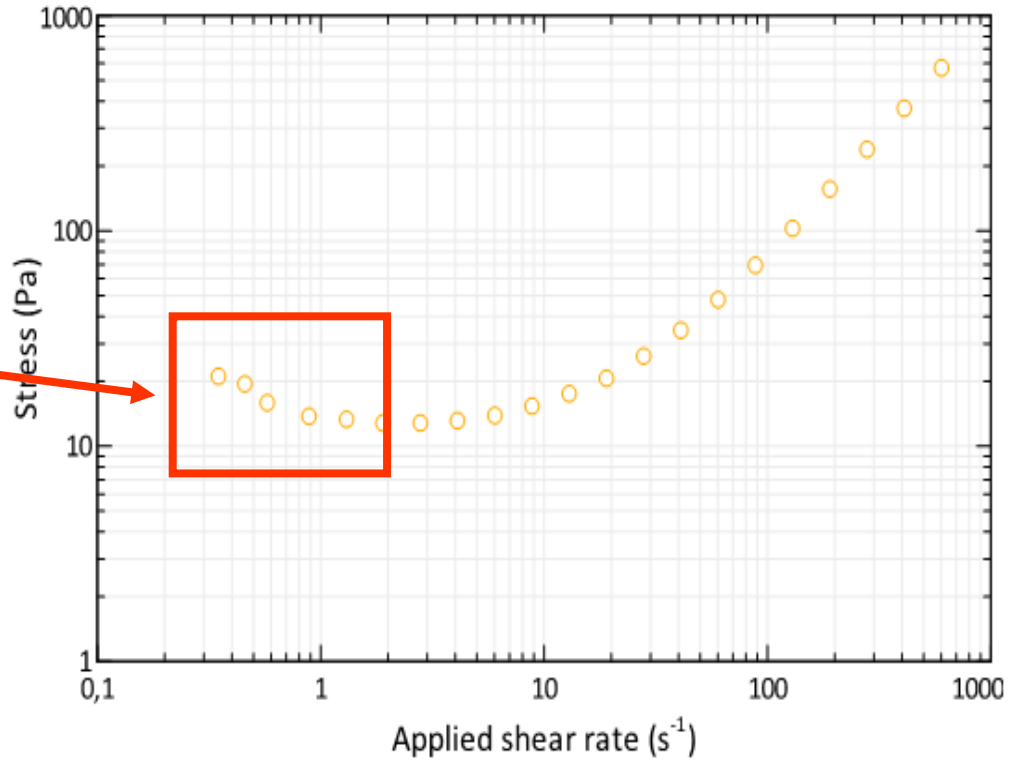
2 - **on viscosity** : re-shearing followed by a 4 Pa continuous rotation (to simulate a gravel sedimentation)



Thixotropy evaluation on grout scale

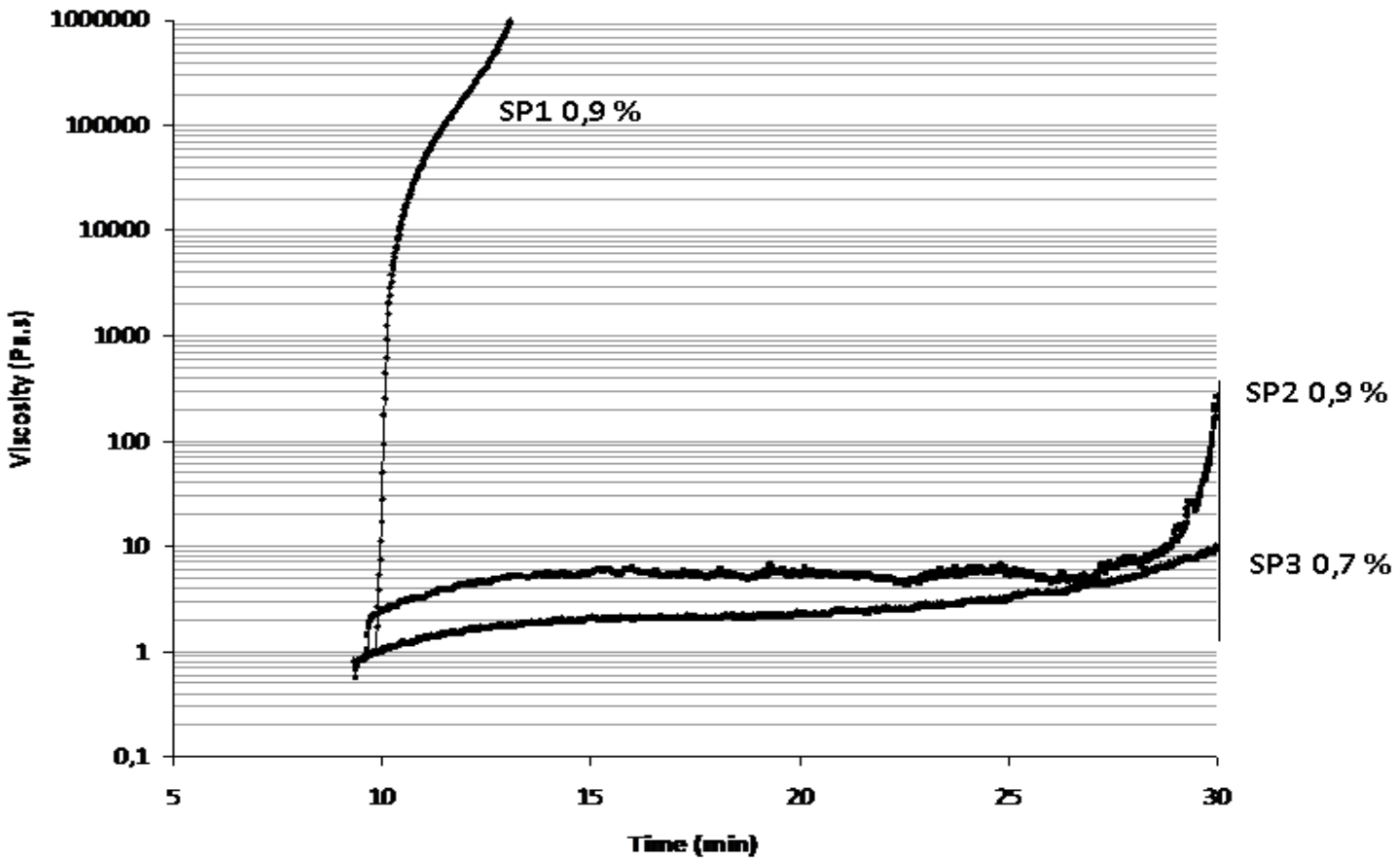
Results : *1- evolution of the shear stress*





Thixotropy evaluation on grout scale

Results : *2- evolution of the viscosity*



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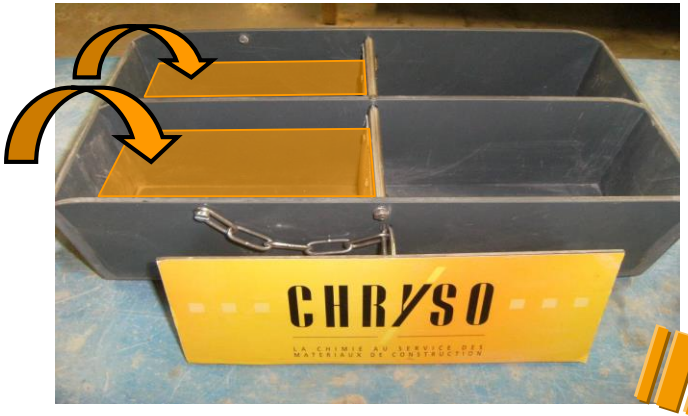
Thixotropy evaluation on concrete scale: lab trials

Test protocol : *evaluation on concrete of the 3 PCP based superplasticizers*

Composition for 1m^3 dry contents (kg)	
Cement CEM I 52.5R	350
Limestone filler	160
0/4 mm sand	642
4/10 mm crushed gravel	859
8/16 mm riverbed gravel	114
Effective water	176

Thixotropy evaluation on concrete scale: lab trials

***Test apparatus : CHRYSO® Box**, a new device developed to test concrete rheology at low energy input*

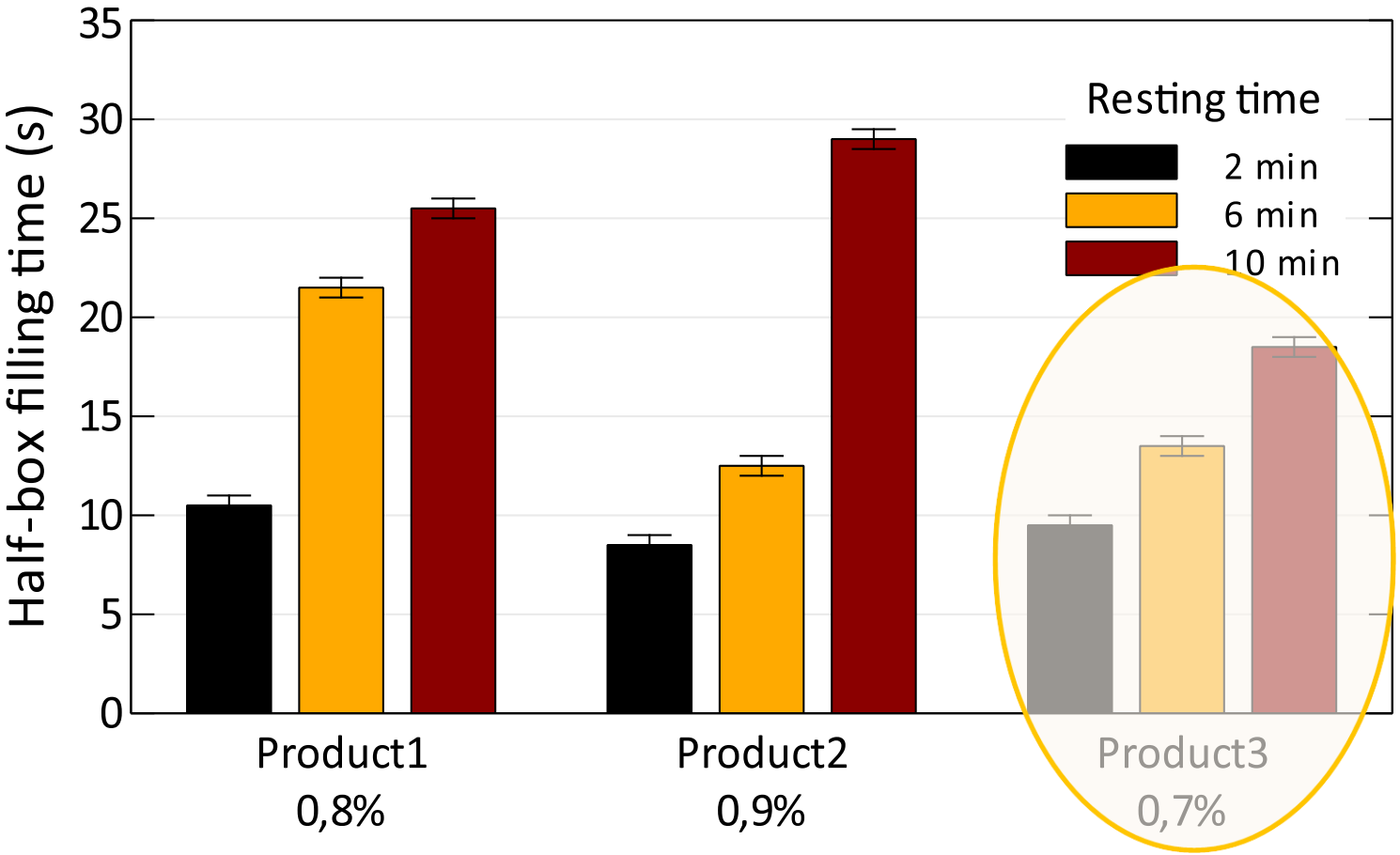


- Box separated in two equal parts by a removable gate;
- Both parts on the left side filled simultaneously with concrete after end of mixing, then lifted 2, 6 or 10 minutes later.

- Time to reach the opposite end at each resting time ;
- Height differences between both ends concrete stops flowing.

Thixotropy evaluation on concrete scale: lab conditions

Results:



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Thixotropy evaluation on concrete scale: industrial conditions

Results: *evaluation in a prestressed beam precast plant*

Cement (kg/m³)	Water (l/m³)	Admixture name	Dosage %	Flow (mm)	Rc 14h (MPa)	Rc 16h (MPa)
433	205	SP3	1.00%	680	47.7	51.3
		Current superplasticizer	1.25%	680	41.8	50.1

Thixotropy evaluation on concrete scale: industrial conditions

Thixotropic concrete (current SP)

Non thixotropic concrete (SP3)

The new superplasticizer brings a faster and better filling of the mould !

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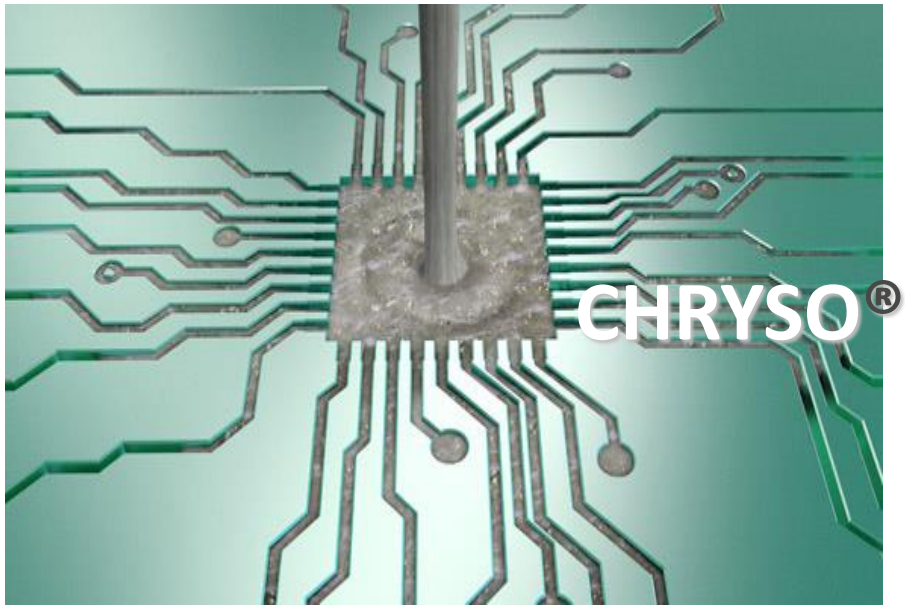
Conclusions

- **The study of thixotropy at grout and concrete scale allowed:**
  - The development of a specific tool, easy to use: **CHRYSO®Box**
  - The development of **a specific polymer chemistry** to reduce thixotropy

FILL-FREE® technology



CHRYSO®Fluid Premia 500 series

Thank you for your attention !