Interreg North-West Europe SeRaMCo

European Regional Development Fund

EUROPEAN UNION

21 January 2021

SeRaMCo Digital final conference

Use of recycled aggregates for cement production

UNIVERSITÉ DE LORRAINE

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Outline

Introduction

I. Laboratory experiments

II. Industrial production

III. Durability

Conclusion

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VICAT

Cerema

Introduction

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Natural materials

+

Recycled aggregates

Cement raw meal (CRM)

+

Firing

Clinker

Introduction

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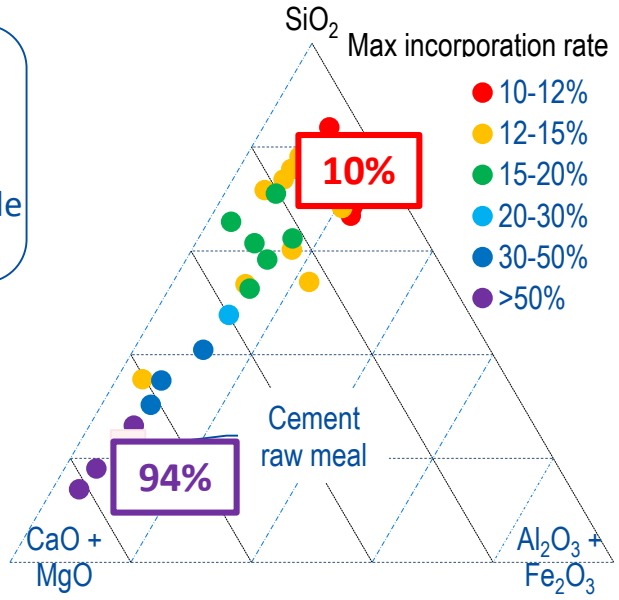
Recycled aggregates incorporation rate[1,2]

Varies widely (10 à 94)%

Impacted by the Silicium-Calcium couple



Depends also on:

- Type of cement plant quarries
- Chemical composition of natural materials
- Type of clinker/cement produced

10% of calculations ▶ < 5%
73% of calculations ▶ 10 to 30%
17% of calculations ▶ > 30%

→ **Incorporation rate of at least 5% is possible for 90% of calculations**

1. H. Krour et al, (2020) «Incorporation rate of recycled aggregates in cement raw meals » Construction and Building Materials.

2. H. Krour, (2020) «Incorporation des déchets de construction et de démolition dans le cru cimentier » PhD Thesis (in French).

I. Laboratory experiments

Laboratory synthesis of cement raw meals (CRM)

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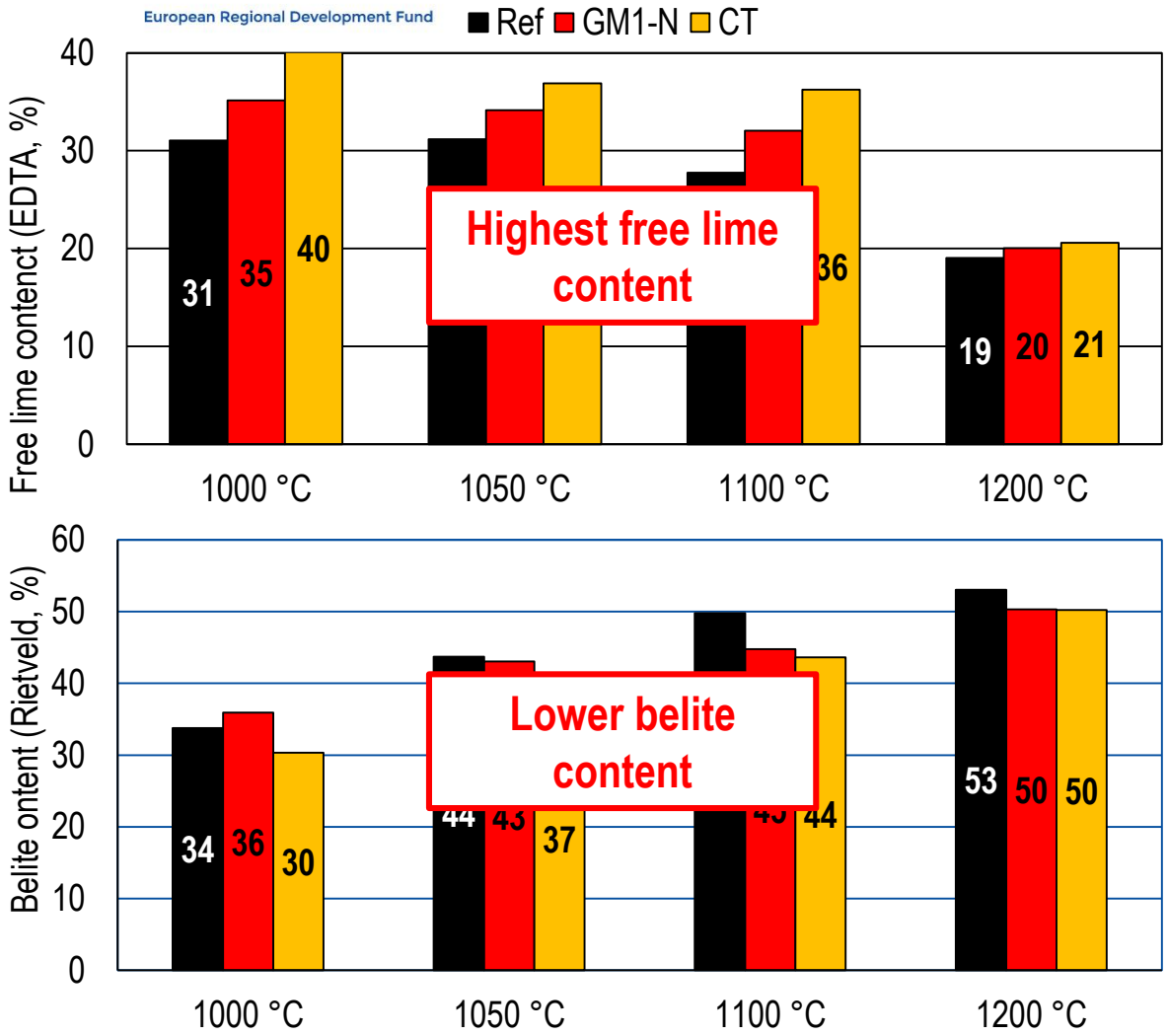
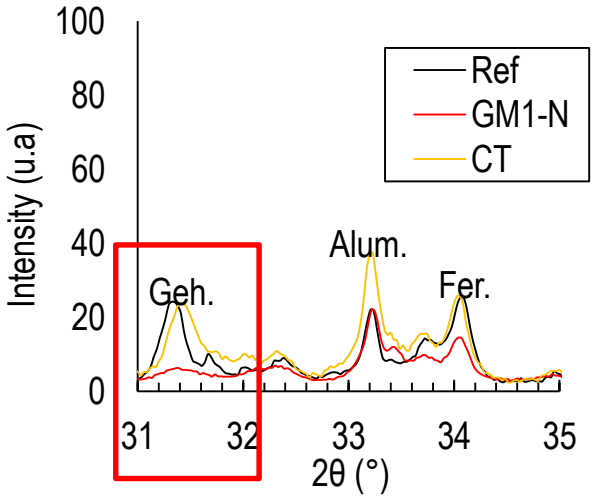


Compared to reference CRM

Reduced burnability

Changes on intermediate phases



I. Laboratory experiments

Laboratory synthesis of cement raw meals (CRM)

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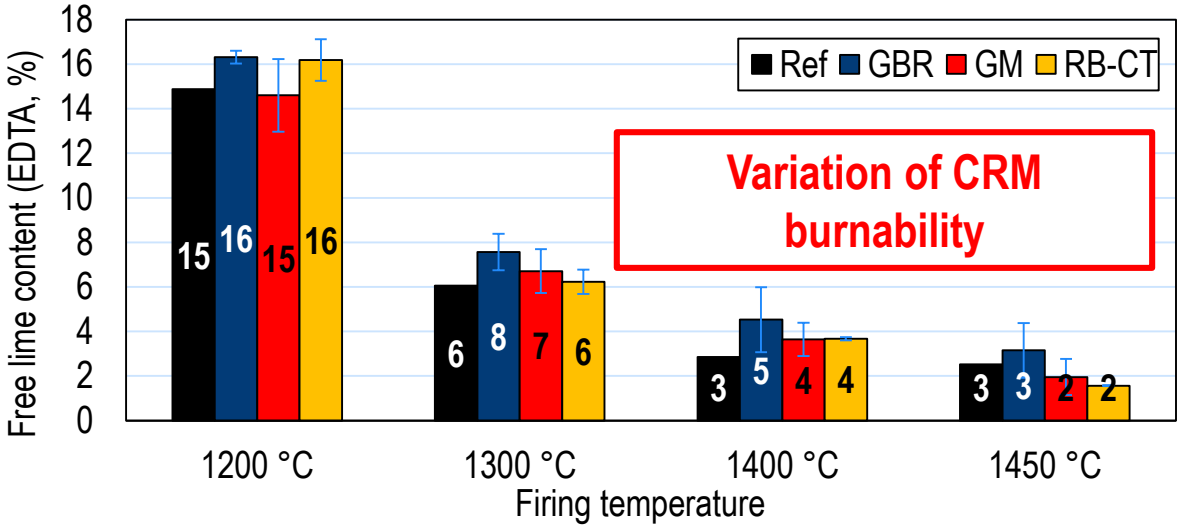
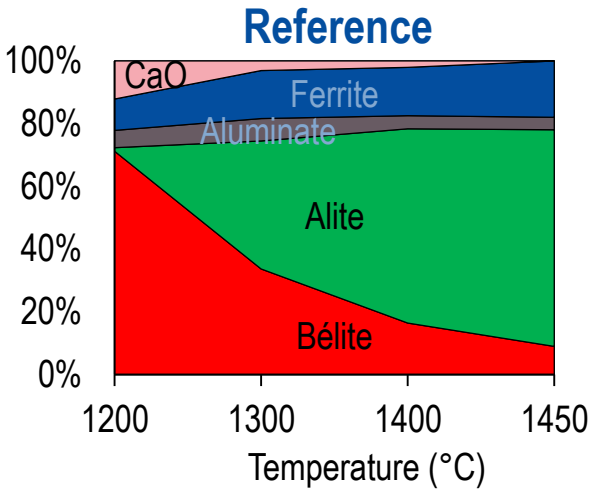
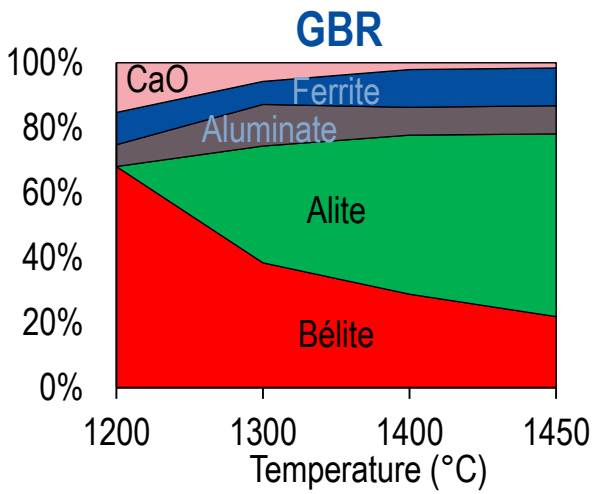
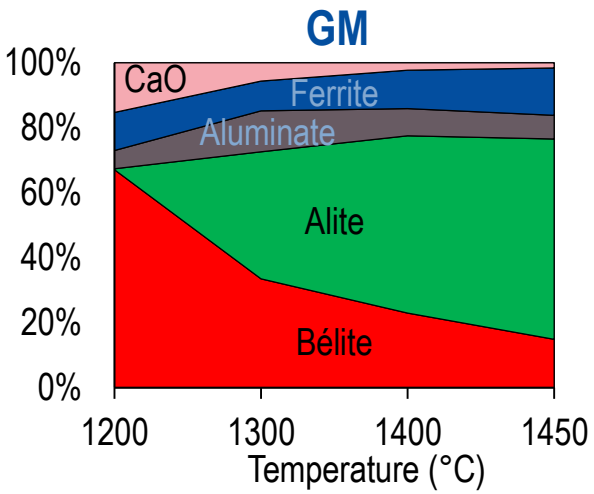


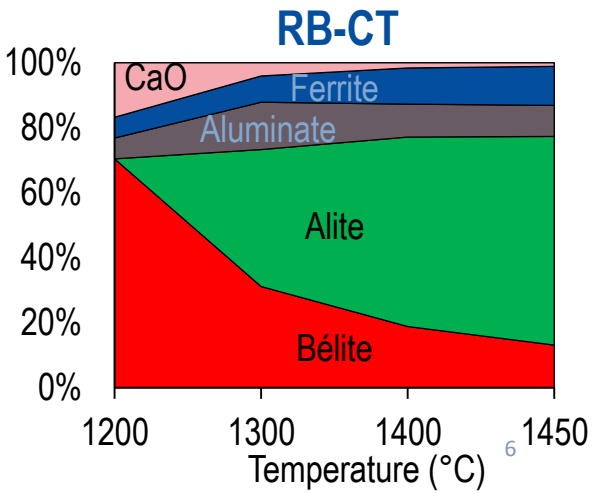
Variation of CRM burnability

Higher belite contents









I. Laboratory experiments

Study of the cement raw meals fineness

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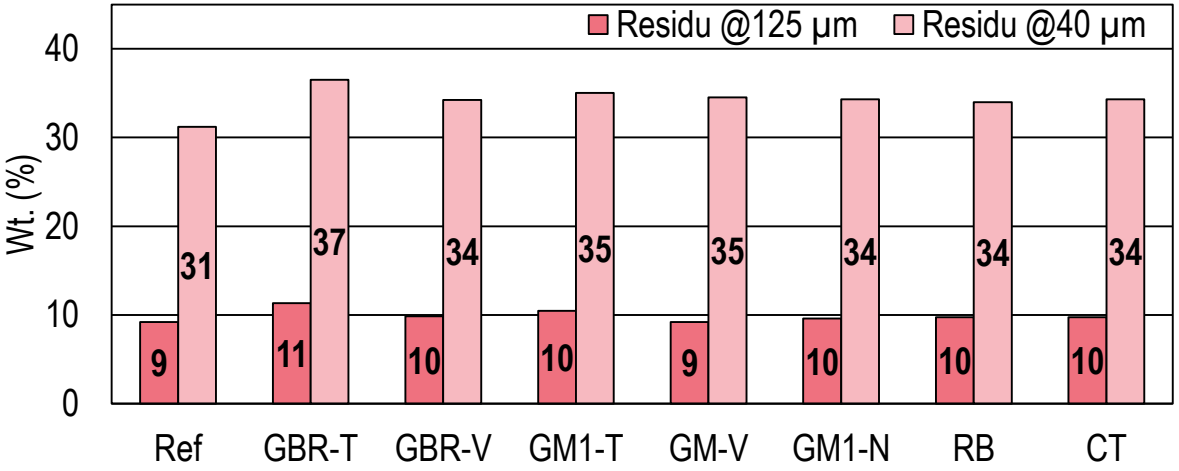

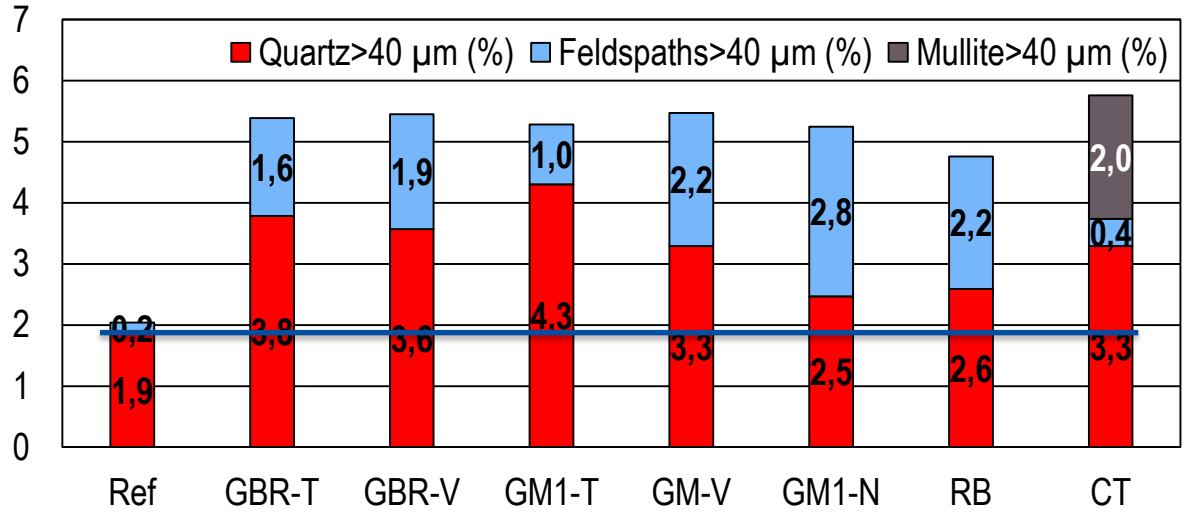

Same fineness for all raw meals

High **quartz and feldspars** contents

I. Laboratory experiments

Study of the reactivity of quartz and feldspars in the kiln

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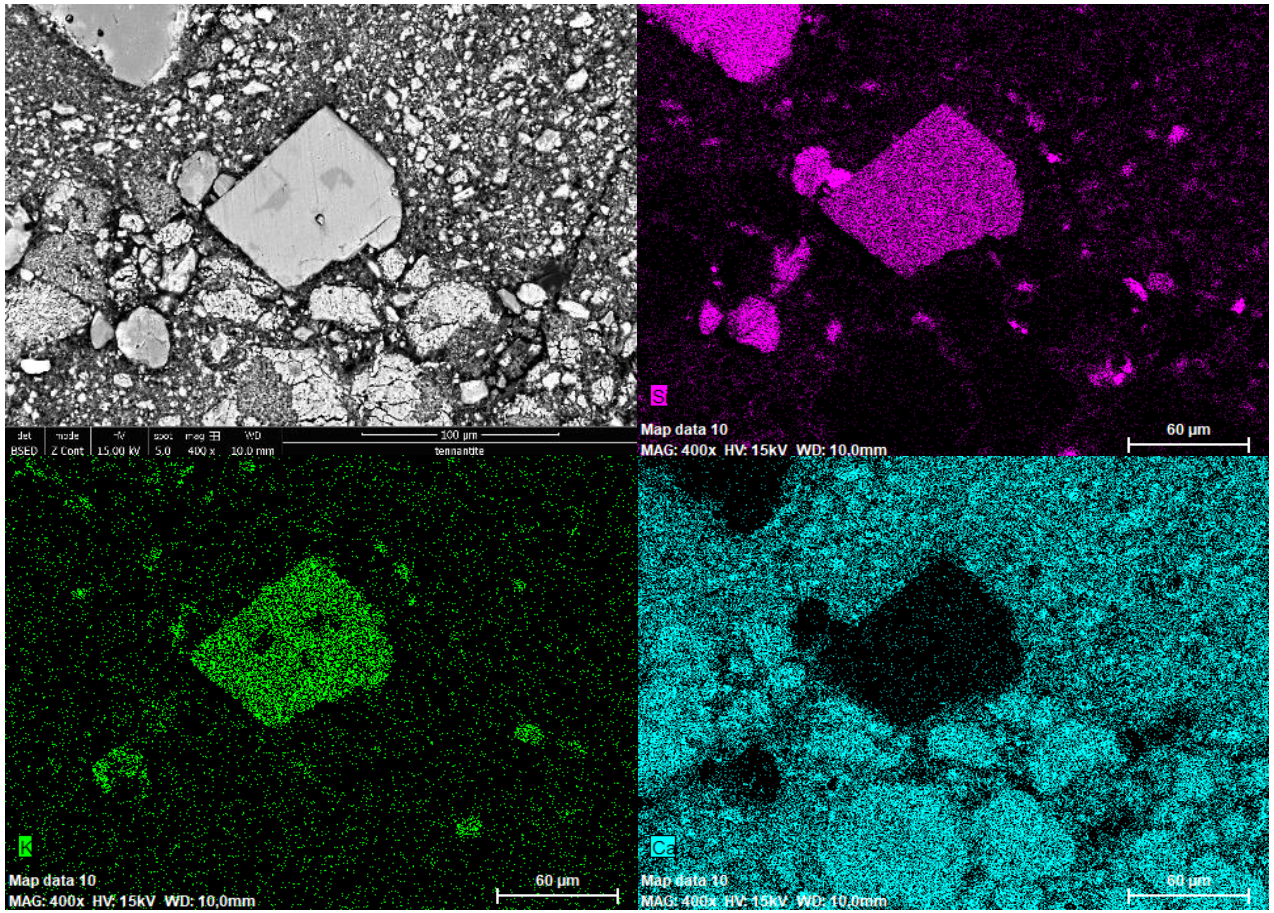
Feldspars in cement raw meal



Recycled aggregates used for the first industrial trial contain high proportions of quartz and **K-feldspars**

Silicium
Potassium
Calcium

I. Laboratory experiments

Study of the reactivity of quartz and feldspars in the kiln

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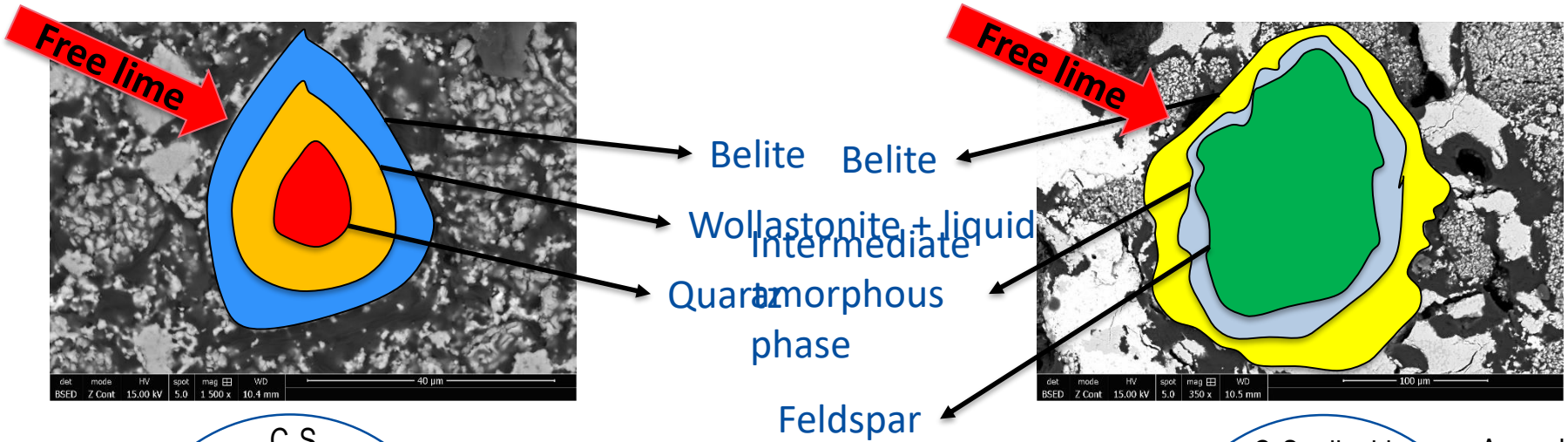
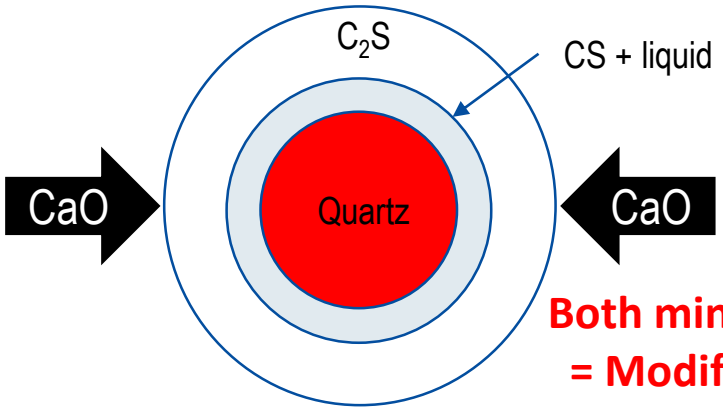
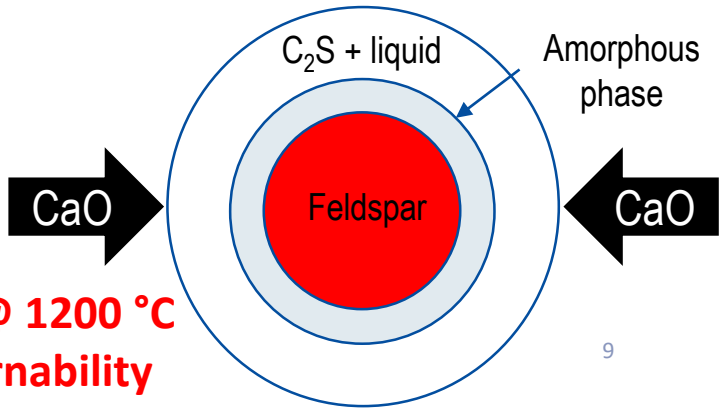
Quartz in cement raw meal @ 1200 °C

Feldspar in cement raw meal @ 1200 °C







Both minerals are still present @ 1200 °C
= Modification of raw meal burnability

I. Laboratory experiments

Characterization of industrial clinkers

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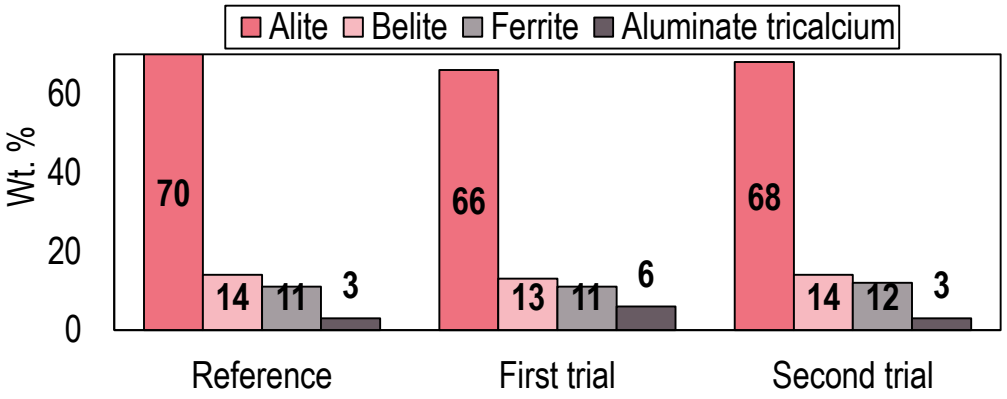
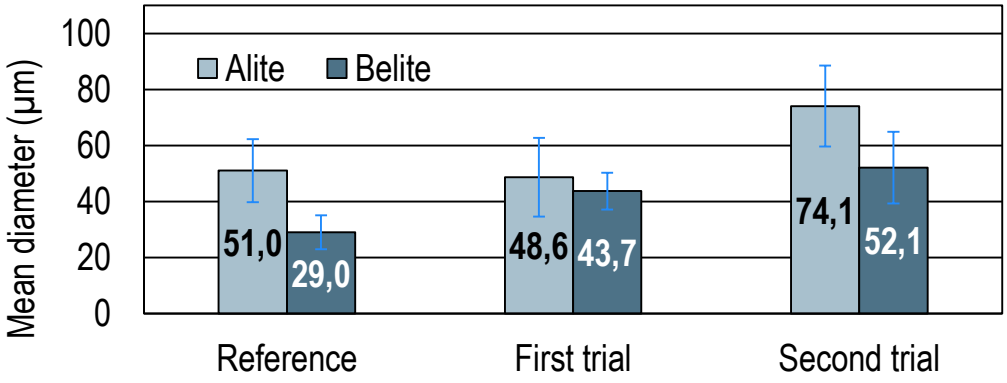
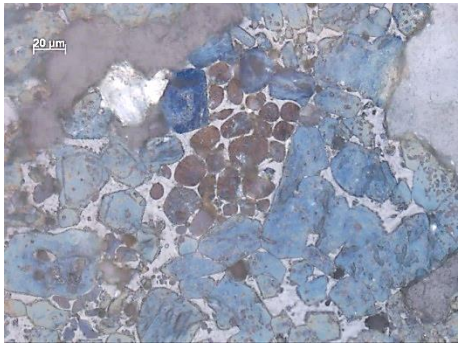


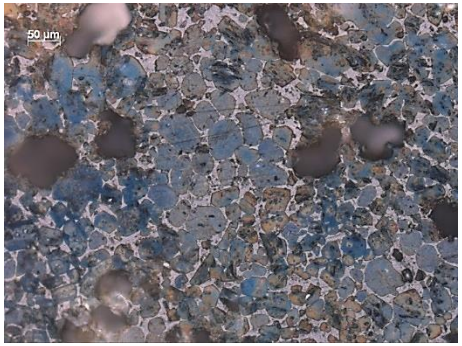
Same mineralogical composition



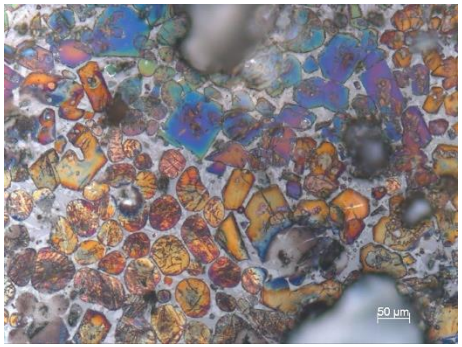
Regular size of alite and belite grains



Reference



First trial



Second trial

I. Laboratory experiments

Characterization of industrial cements

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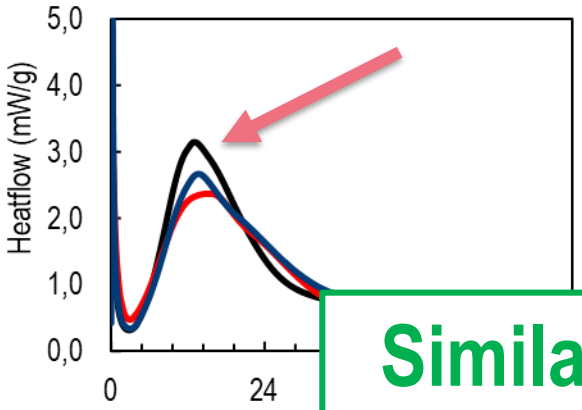
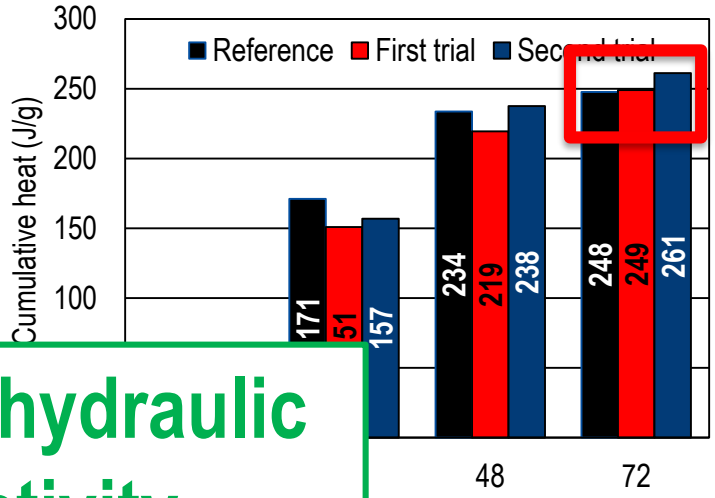
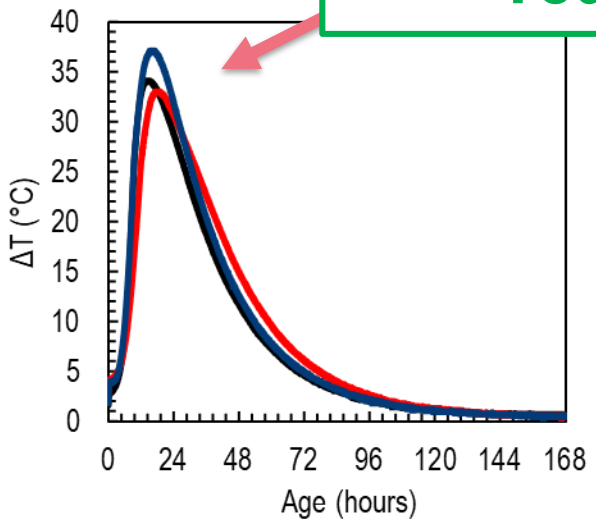
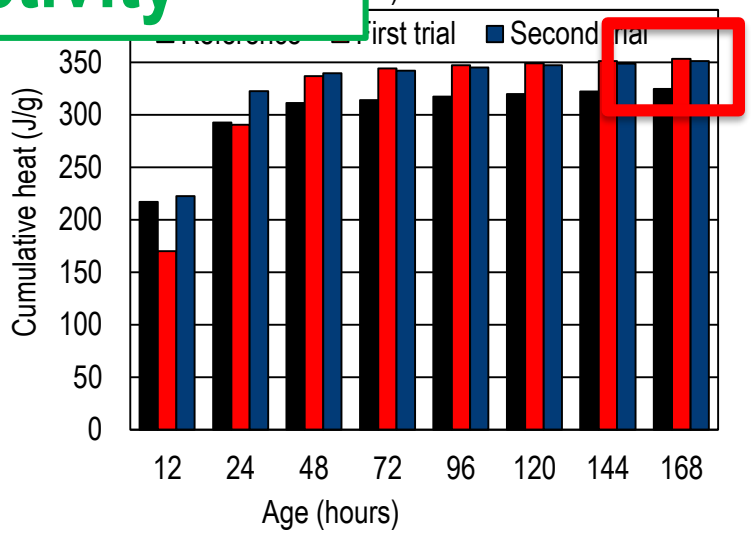




Similar hydraulic reactivity





Cement paste

Cement mortars

I. Laboratory experiments

Characterization of industrial cements

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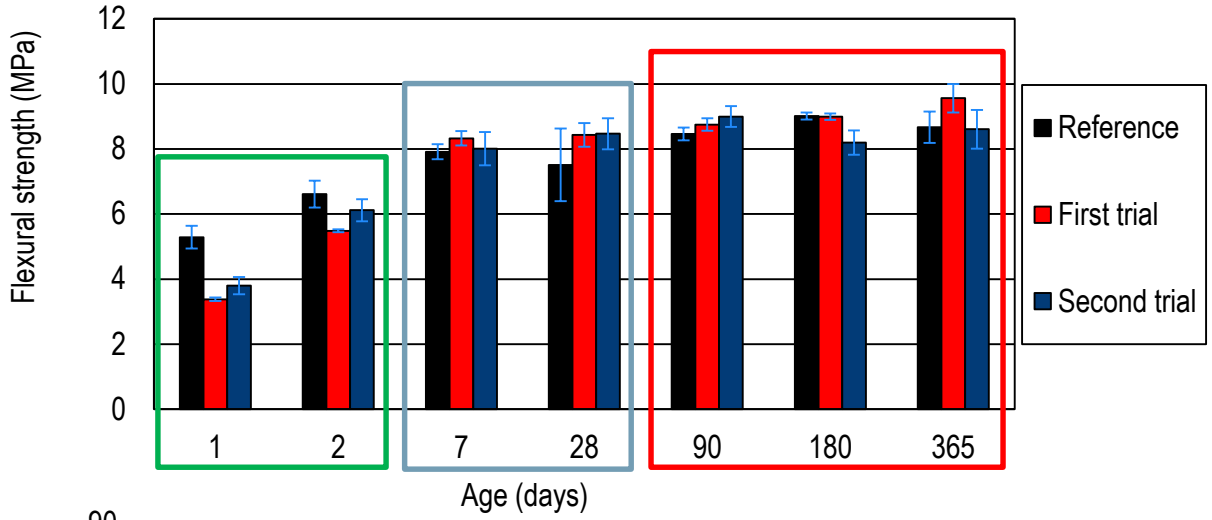

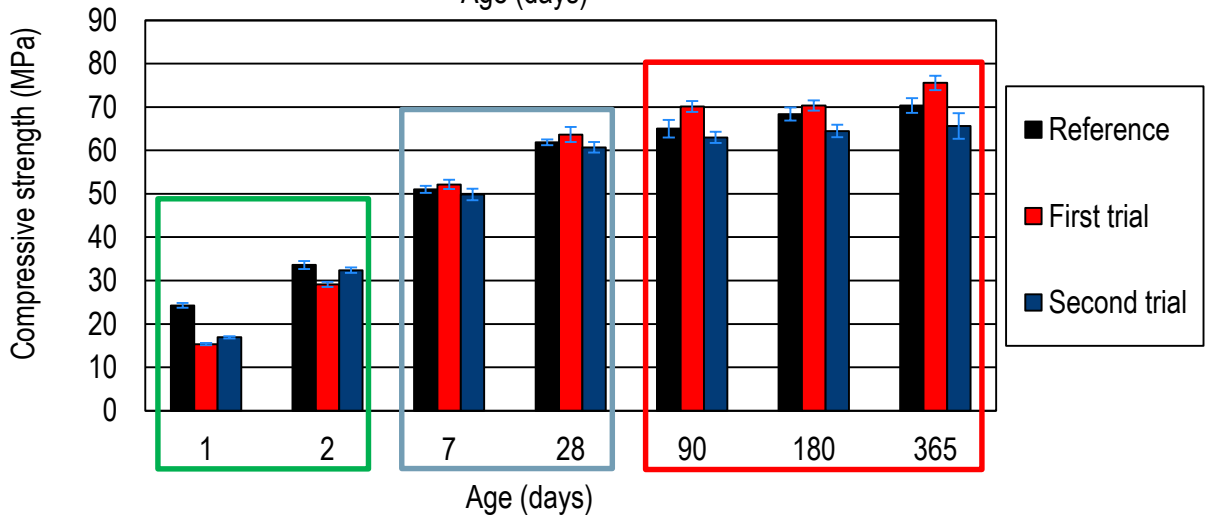

Similar mechanical properties

Conclusion

Laboratory experiments

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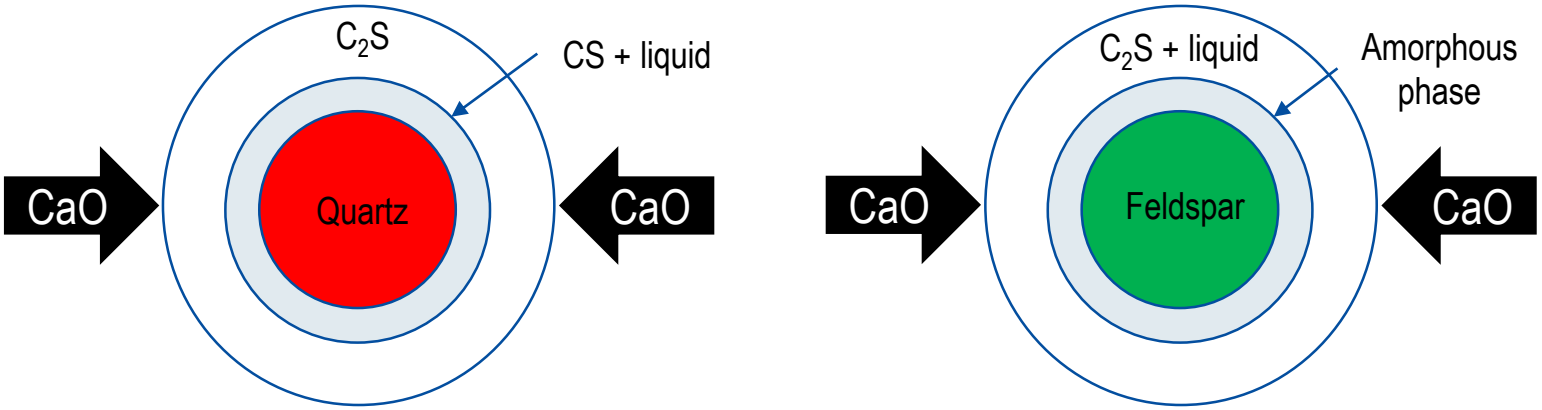
→Industrial trials and laboratory synthesis confirm clinker quality but …

Use of RAs at high incorporation rate = higher quartz and feldspars content in the raw meal for (d>40 µm)

✓ Study for better understanding of quartz and feldspars reactivity in the kiln



Both minerals are still present @ 1100-1200 °C
= Modification of raw meal burnability

II. Industrial production

VICAT cement plant in Créchy, France

II. Industrial production (Créchy cement plant)

Last cement plant greenfield in France

Built in 1968

Leader in reducing the consumption of fossil fuel

> 80% of the energy needed for the burning is produced thanks to alternative fuel

70 workers

Open 24/7

2018 Innovation
Commisioning of a gasifier
A world first!!!

Raw material substitution :

The plant is substituing
10% of natural ressources
(limestone and marl) thanks to the valorisation of mineral by-products coming from other industries

Raw materials

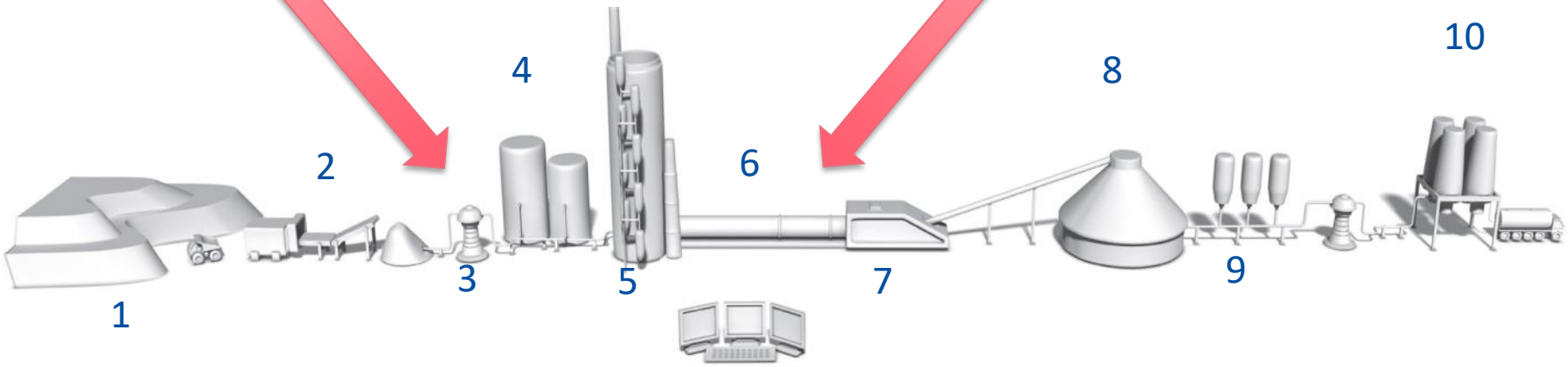
Natural
- Limestone
- Marl/ clay
- Bauxite
- Iron ore
- Gypsum

Alternative
- Foundry sand
- Ashes
- Iron oxydes
- Excavated soil
- Plasterboard
- Etc.

Fuels

Fossil
- Charcoal
- Petcoke
- Heavy oil
- Gas

Alternative
- Waste wood
- Oil / Solvents
- Animal meal
- Tires
- Dried sewage sludge
- Etc.



- 1: Quarry
- 2: Pre-homogenisation pile
- 3: Raw feed mill
- 4: Storage
- 5: Pre-heater Tower
- 6: Kiln
- 7: Cooling
- 8: Storage
- 9: Cement mill
- 10: Storage, packing, loading

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Créchy cement plant

Alternative raw materials:

Alternative fuels:

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Créchy cement plant
2 full-scale trials

- 1st trial, September 2018, production of 3,000 t of clinker
  - Raw materials included 14.2% of recycled aggregates
  - Over-consumption of energy (~20%)
  - Impact on the quality of the clinker
  - Production of 5 t of cement for SERAMCO partners
- 2nd trial, July 2019, Production of 2,500 t of clinker
  - Raw materials included 5.2% of recycled aggregates
  - No over-consumption of energy
  - Good quality clinker
  - Production of 55 t of cement for SERAMCO partners

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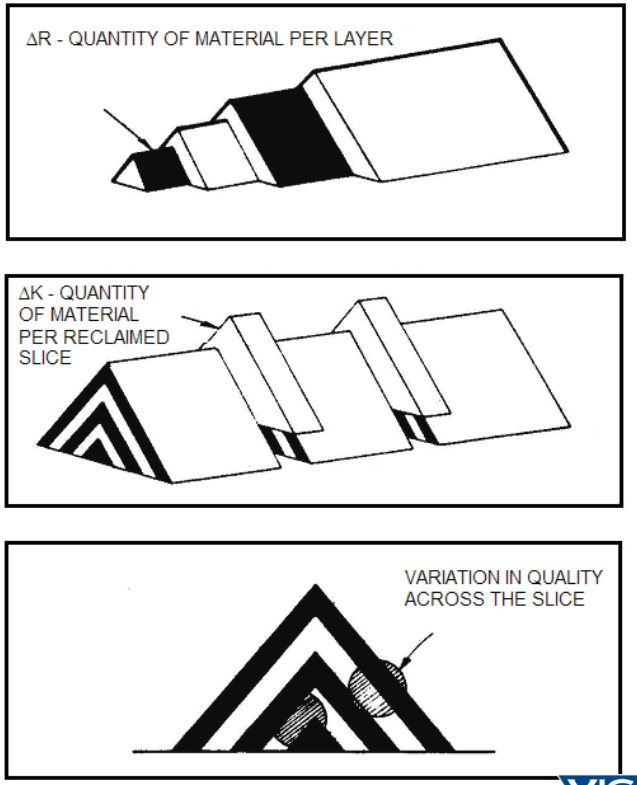
- Stacking of raw material including 4.6% “mixed fines” delivered by TRADECOWAL (271 tons), equivalent to an annual consumption of ~50 kt/yr
- Pre-homogenisation



Costa et al, Jan 07 Reserchgate

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- Milling of the pre-homogenisation pile
- Final adjustment of the chemistry by adding bauxite and iron oxide
- Storage and homogenisation of the raw feed
- Firing of the raw feed

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- Production of 2,500 t of clinker
  - Good quality clinker
  - No over-consumption of energy
  - 65% C3S
  - 1.67% free lime
- Storage in Créchy before transfer to VICAT R&D pilot center in Chambéry, France

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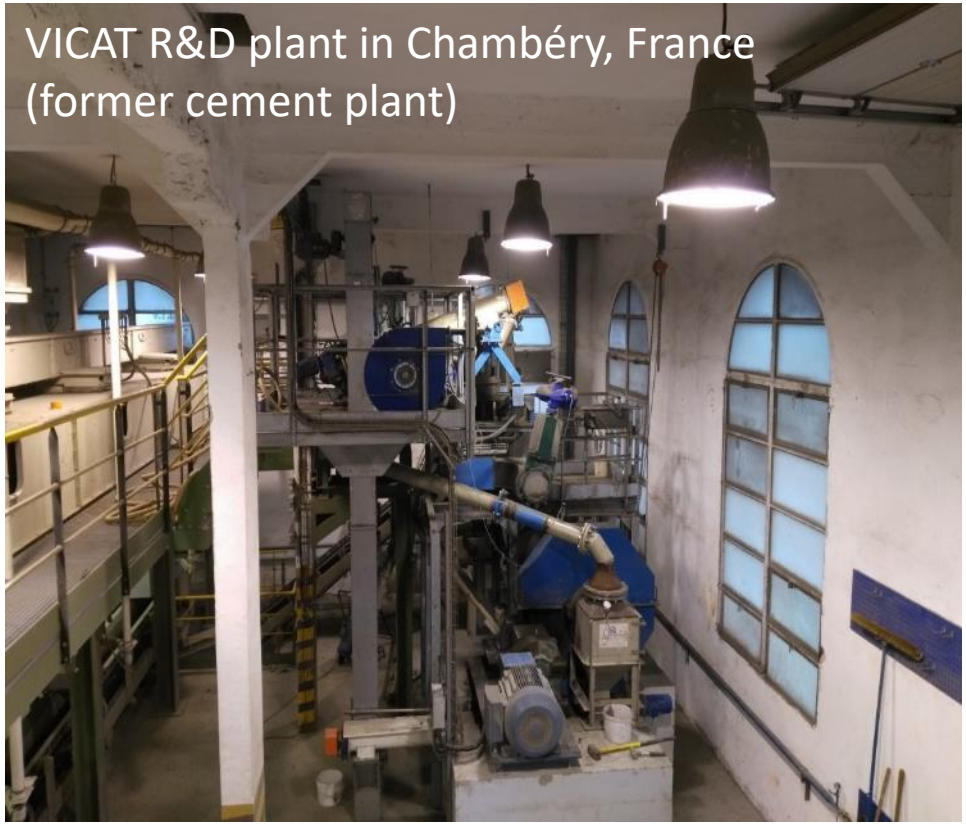

- R&D ball mill pilot
  - Same sulfate source and content
  - Comparable fineness: measurement of Blaine fineness and PSD
- Production of 55 t of CEM I 52,5 N :
  - 35 t PREFER
  - 14.5 t BETON BETZ
  - 3 t TU KL
  - 2 t TU Delft
  - 0.4 t Uni Liège
  - 0.2 t Uni Lorraine

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III. Durability

Mechanical properties of concrete

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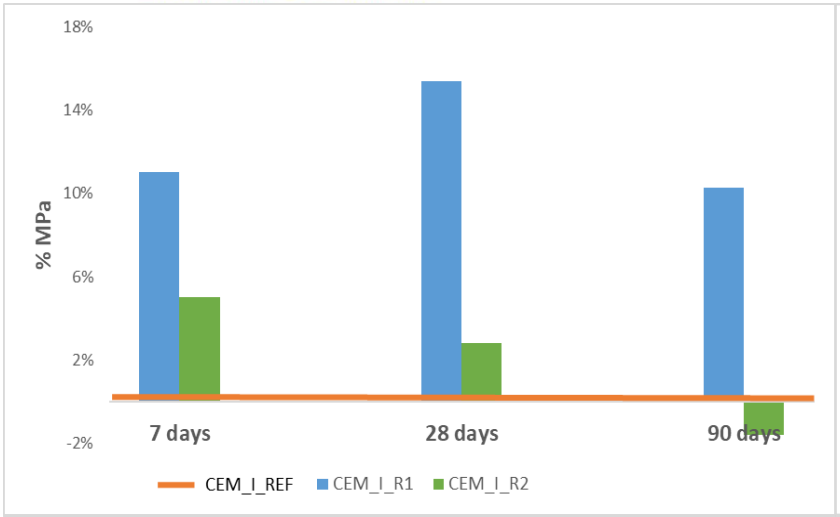

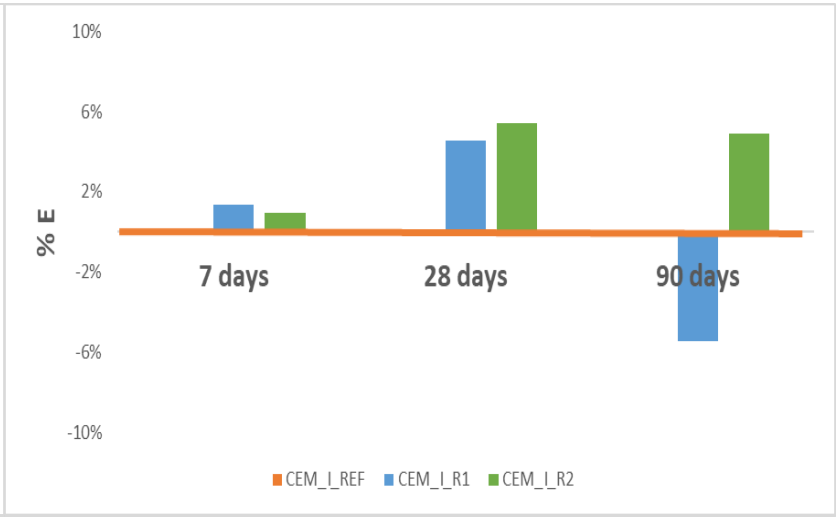

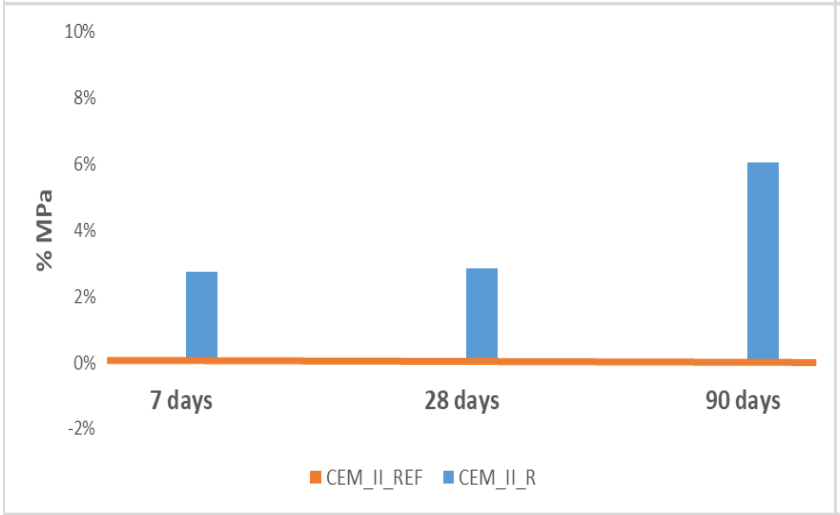

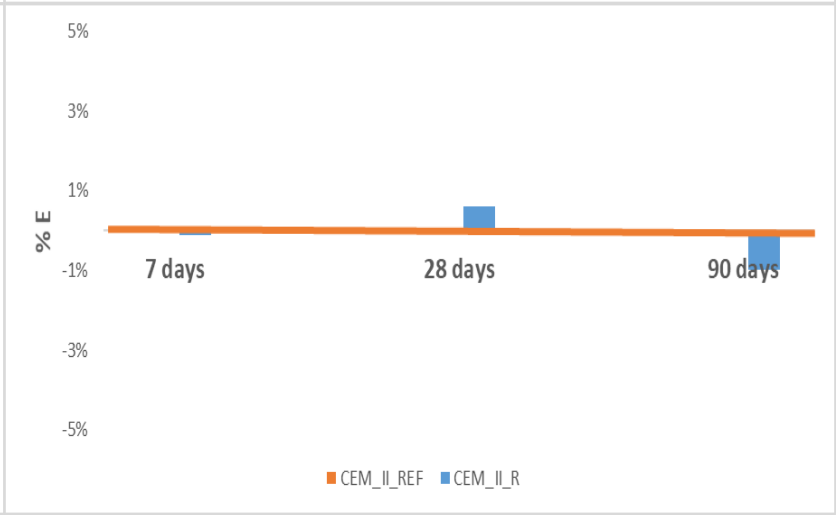

III. Durability

Durability parameters of concrete

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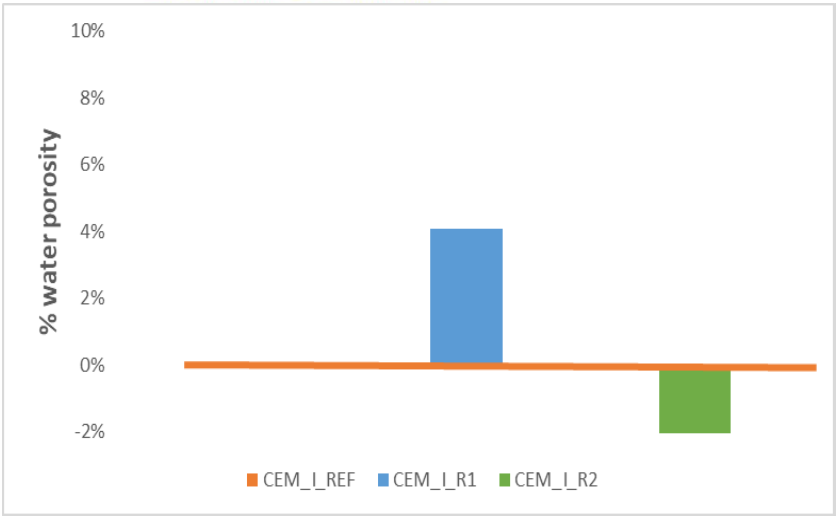

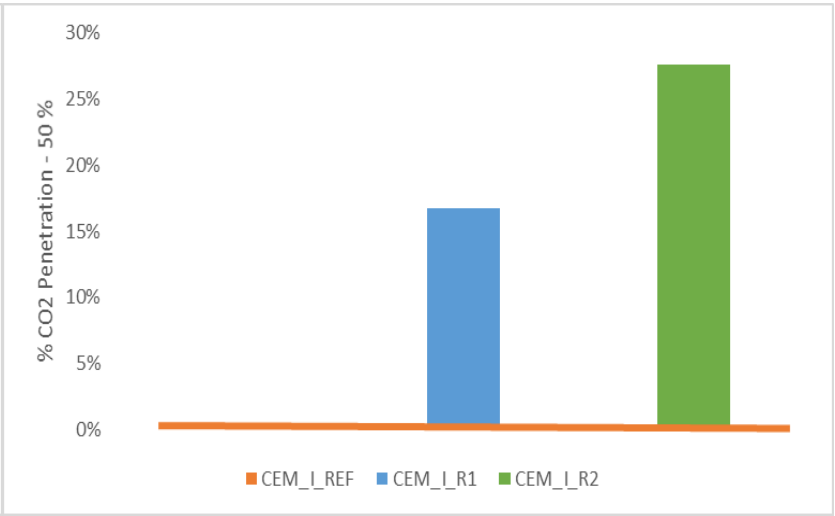

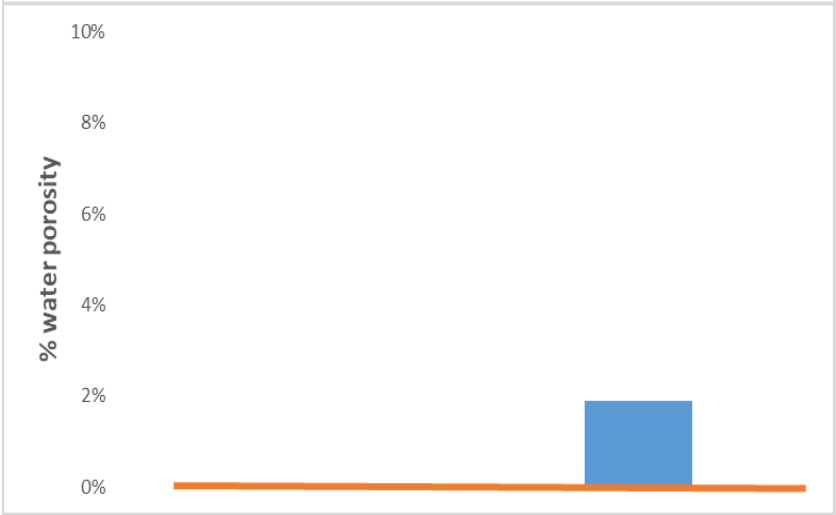

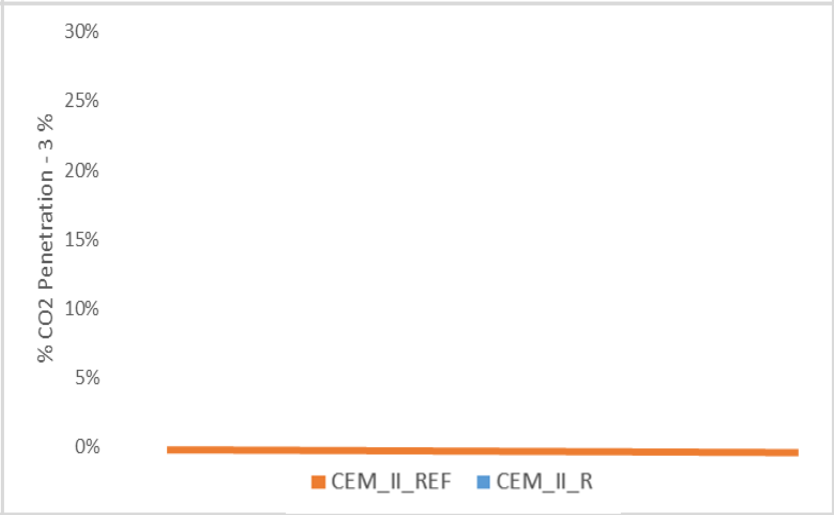

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Thanks for your attention!

Questions?