N°1

PILOT CLINKERING:
FROM LABORATORY TO PILOT SCALE

Solid Life Project

Plants assessment

- More than 30 different european clinker production lines from LafargeHolcim have been assessed for Solidia clinker production:
  - Thermodynamic simulations have been performed for each plant based on the available raw materials chemistries.
  - Plants process assessment and production feasability estimation were performed.

Successful completion of Solidia pilot trial in a rotary kiln

- 5 different raw mixes tested with different raw materials coming from two LafargeHolcim plants: Koromacno (Croatia) and Malagoszcz (Poland). Limestone and marls (as calcium sources) were tested with different sands (as silica sources).
- Raw materials received were analysed by XRF and milled in the right proportions to reach the targeted chemistries.
- Lab static kilns were used to assess the potential clinker quality.
- Clinker quality was followed by X-Ray Diffraction measurements coupled to Rietveld file in order to assess the amount of reactive phases and comparison to thermodynamicsimulations.
- Thermodynamics simulations performed were successfully compared to lab results.

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Solid Life Project

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- Five different raw mixes tested with different raw materials coming from two LafargeHolcim plants: Koromacno (Croatia) and Malagoszcz (Poland). Limestone and marls (as calcium sources) were tested with different sands (as silica sources). Two tonnes of each clinker were produced.

- Pilot test was realised at IbuTec facilities in Weimar using a two stages preheater kiln equipped with a rotary cooler. This trial enabled to confirm the robustness of the solution towards clinker production and its ability to be produced in rotary kilns.

- A more narrow temperature range is nevertheless required in the burning zone for Solidia clinkering towards Portland clinker. This point shows the need of a higher level of control in order neither to be under burnt, neither over burnt. Being too high in temperature leads to high amount of liquid phase and risks of rings formation in the kiln, and being too low leads to less elements combination to get the targeted reactive phases (CS, wollastonite and C_3S_2 Rankinite).

- Clinker quality was mainly followed by X-Ray Diffraction measurements coupled to Rietveld file in order to assess the amount of reactive phases.

DURABILITY ASSESSMENT:
FROM LABORATORY TO INDUSTRIAL CONCRETE SPECIMENS

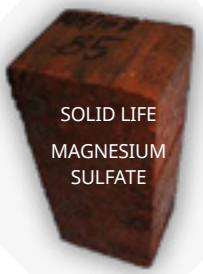
Solid Life Project

Durability measurements on laboratory concrete specimens

- Laboratory prepared concrete specimens, (from two different concrete mixes with similar mix design; one Solidia cement; one Portland cement reference concrete) were made by Solidia Technologies. These were assessed by BRE for their resistance to abrasion, freeze/thaw resistance, shrinkage and creep behaviour (long term deformation under a sustained compressive load). The resistance to abrasion and freeze thaw was good and very similar in both mixes. The Solidia concrete showed significantly less creep deformation and lower drying shrinkage % (over 3 months) than the PC reference mix.

Long-term durability assessment on industrial block pavers

- Two types of concrete block paver products were produced in plant trials by a UK pre-caster (Solidia cement and Portland cement reference). These have been placed by BRE into exposure conditions for long term exposure to natural weathering (inland and coastal sites in Southern England) and in aggressive solutions (seawater, acid, sulfates). Specimens are also stored in air or water for assessment of long term shrinkage or expansion. A combination of visual monitoring of deterioration, strength changes, composition and monitoring dimensional changes is planned depending on the exposure conditions.



N°2

DURABILITY ASSESSMENT:
FROM LABORATORY TO INDUSTRIAL CONCRETE SPECIMENS

Solid Life Project

Laboratory durability assessment for standardization preparation (ETA)

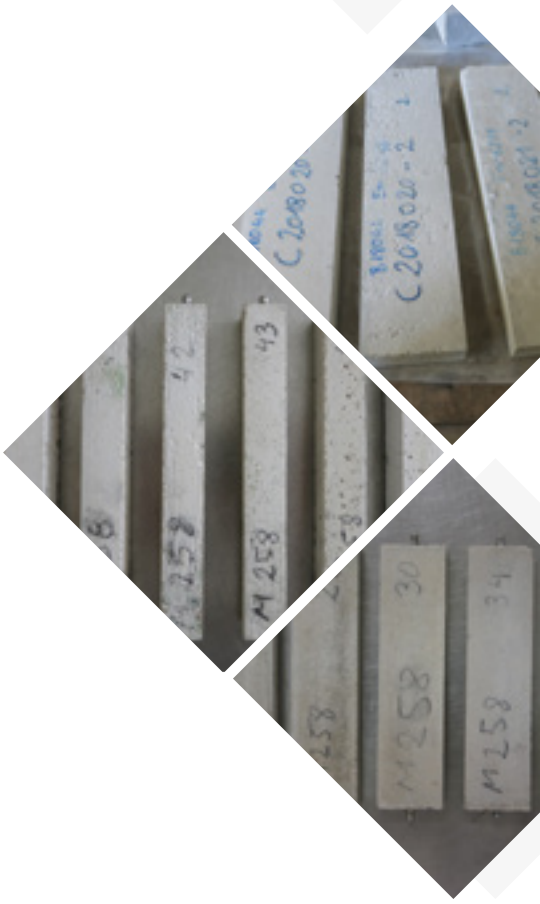
- Mortar specimens were prepared from Solidia binder in the CTEC lafargeHolcim's Lab curing equipment programmed by Solidia Technology's experts.

- After successful carbonation, the specimens were subjected to various tests to evaluate the behavior under different environmental surrounding. All tests were carried out in comparison to OPC standard mortar specimens as required for the European Technical Approval (ETA).

  The impact of chemical attack by sulfate solution, acidic or alkali environment was studied over weeks – without detection of inferior resistance of the Solidia specimens as compared to their OPC reference counterparts.

  In standard tests using temperature-controlled climate chambers, the specimens' behavior in harsh winter condition was assessed by repeated freezing and thawing of the specimens in water and in the presence of salt solution, respectively.

- All these results were regrouped and used to build an EAD document on the Solidia binder. Long term exposure tests will enable to continue to assess Solidia concrete behaviour.



PRECAST APPLICATIONS:
FROM PILOT TO INDUSTRIAL SCALE

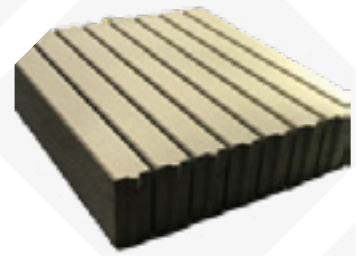
Pilot precast tests

Five different pilot precast trials occurred during the timeframe of the Solid Life project: UK, Italy, Sweden, Belgium and France.

These pilot tests consist in providing a mobile curing equipment, Solidia cement and CO_2 in bottles to a precast site in order to explain and show the advantages of the solution:

- Rapid strengths acquisition (less than 1 day // several days for OPC)
- Aesthetics advantages (light colours, less pigmentation, no efflorescence…)
- Reduced inventory for precasters
- Fast equipment clean-up: up to 2 hours/day additional production
- Reduced concrete waste because of no hardening without CO_2
- Up to 70% reduction in CO_2 footprint
- 80% of process water recycled
- …

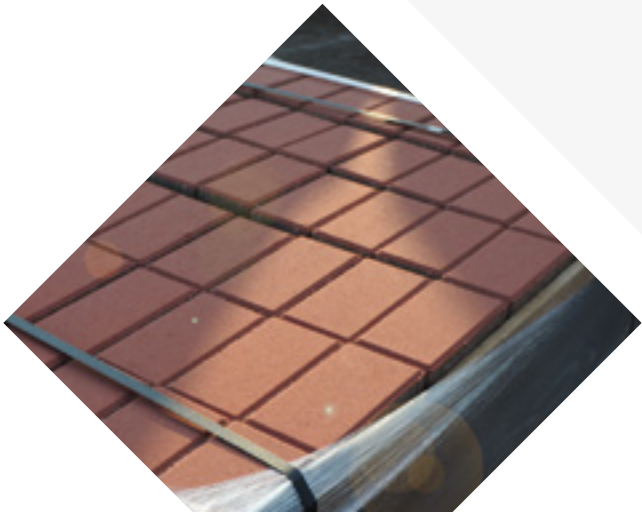
All these advantages were assessed with the precasters to build a representative business model adapted to each specific case.



PRECAST APPLICATIONS:
FROM PILOT TO INDUSTRIAL SCALE

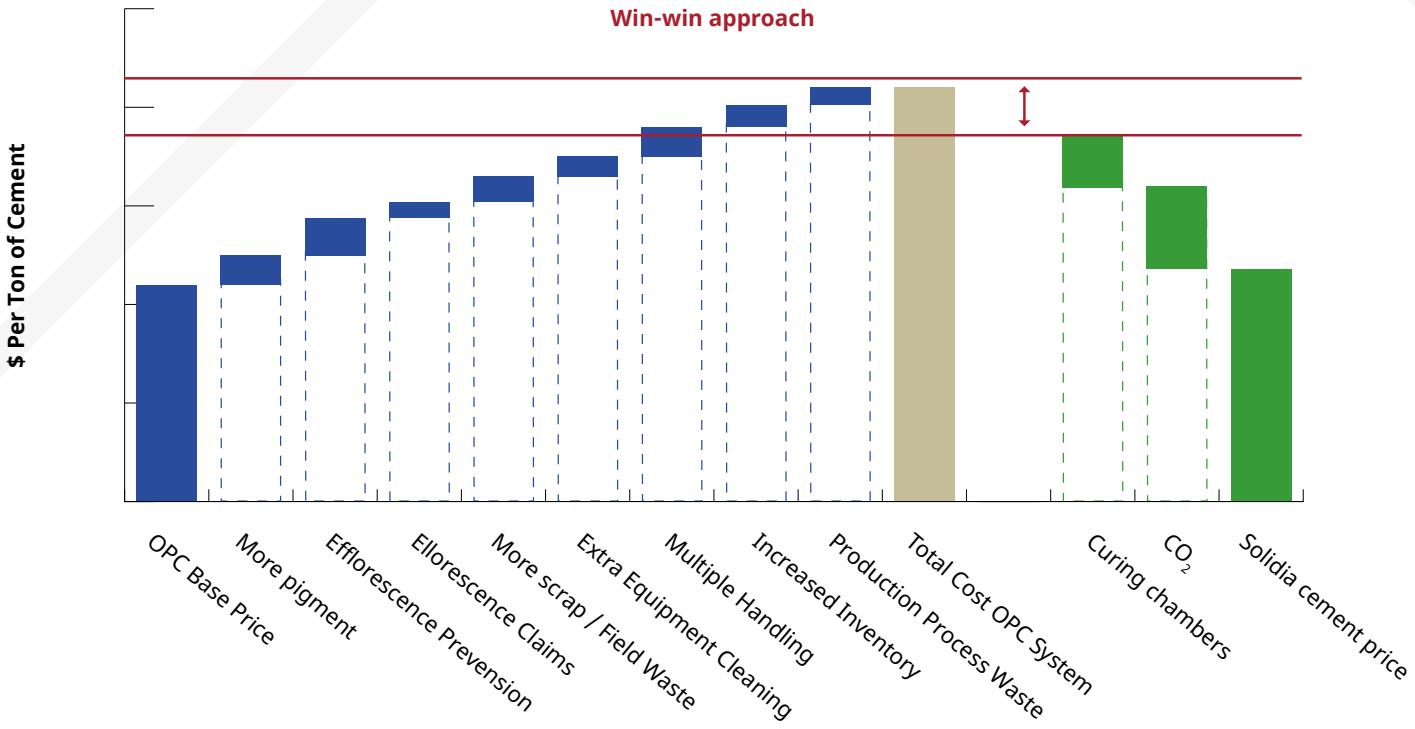
Industrial precast applications:

- After one of the pilot precast trials, a UK precaster decided to move one step ahead and installed an industrial curing chamber on its production site. More than 30 production runs were performed to assess the solution at a bigger scale. One run represents 110 boards of pavers and 15 tons of concrete.
- Strengths and freeze-thaw requirements were achieved for some of the runs. The industrial curing chamber consists in a container whithin gas flows and temperature are controlled to ensure an optimized carbonation reaction. After one day of CO_2-curing, pavers were unloaded and tested.



Business model approach: a win-to-win solution

- Previous to Solid Life project, a business model was elaborated in between Solidia technologies and LafargeHolcim. This model is based on the sales of an integrated offer: cement, curing chambers and associated expertise and CO_2. The cement is fabricated in LafargeHolcim cement plants and transported to precasters' sites, the CO_2 (captured on industrial sources) is bought to a gas provider and the curing chambers are provided by Solidia Technologies.
- The principle of the business model is to take into account and value all the advantages of the usage of Solidia cement towards Portland cement to propose a win-win approach to the precasters: a final lower usage cost of the Solidia cement into concrete (vs. OPC) taking into account the additional costs associated to the technology: CO_2 and curing chambers.
- In order to optimize the business model and to find new opportunities, many studies were performed in the framework of Solid Life especially related to CO_2. CO_2 represents a cost for the technology and actually only food grade CO_2 is available on the market. This grade (99,8%) is not necessary to apply the technology, therefore colocations studies have been performed: a European mapping of industrial CO_2 sources, precast plants and LH cement plants; CO_2 capture technologies assessment...

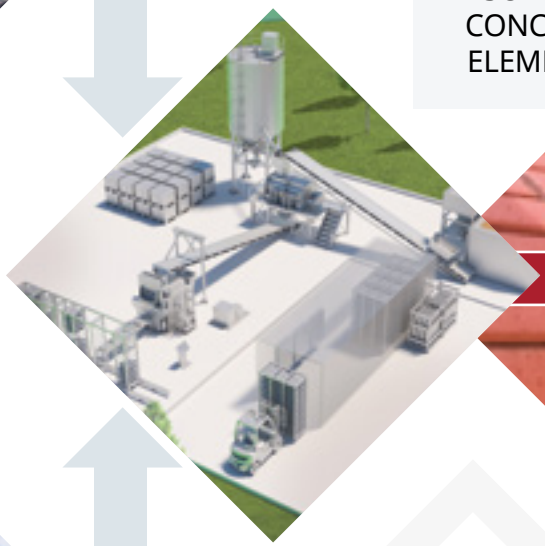


Circular economy assessment around Solidia Technology

- The mapping study proves that synergies are possible within Europe. CO_2 costs could be reduced by capturing it directly from industrial flue gases and using it in a gaseous phase (up to 5 km pipeline around the source would be economically viable). The liquefaction phase engenders extra costs mainly related to installation CAPEX.

100 km around LH cement plants (CO_2 and precast, 5km)

SOLIDIA CEMENT



SOLIDIA CONCRETE ELEMENTS

CO_2 FROM INDUSTRIAL SOURCES