Solidia Technologies: an example of Carbon Capture and Utilization

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Solidia Technologies

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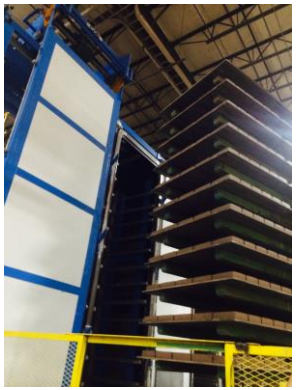
Solidia Cement: a Low-Calcium Silicate Cement (CSC)

Who is Solidia Technologies?

- US start-up founded in 2008
- Funding: $80 Millions from investors
  - Kleiner Perkins Caufield & Byers, Bright Capital, BASF Venture Capital, BP Ventures, LafargeHolcim, Total, Air Liquide, Oil & Gas Climate Initiative…

Development of a non-hydrating binder that reacts with CO_2 for precast concrete



Solidia Technologies solution

Technical solution: cement & concrete

- Same raw materials

- Same kiln

- Same mix components
- Same mixer
- Same cycle time

- Same forming casting
- Same cycle time

- CO_2-Curing
- Reduced curing times (24 hours vs. 28 days)

Solidia Cement™

CO_2 emissions at cement plant reduced by 250 kg (per ton of clinker)

Solidia Concrete™

Up to 300 kg of CO_2 permanently stored in concrete (per ton of cement used)

From partnership to commercial agreement

Partnership LafargeHolcim / Solidia Technologies

- Step 1 – August 2013: JDA between Lafarge and Solidia Technologies
- Step 2 – January 2015: Commercial agreement

Commitments Lafarge/Solidia : 5 + 5 years

Feasibility study
Pilot trial

Industrial Demonstration

Business Model (binder)

Commercial agreement

August 2013

March 2014

January 2015

December 2016

20t IbuTec

5000t WHL

5000t PECS

5000t WHL

Solidia Concrete

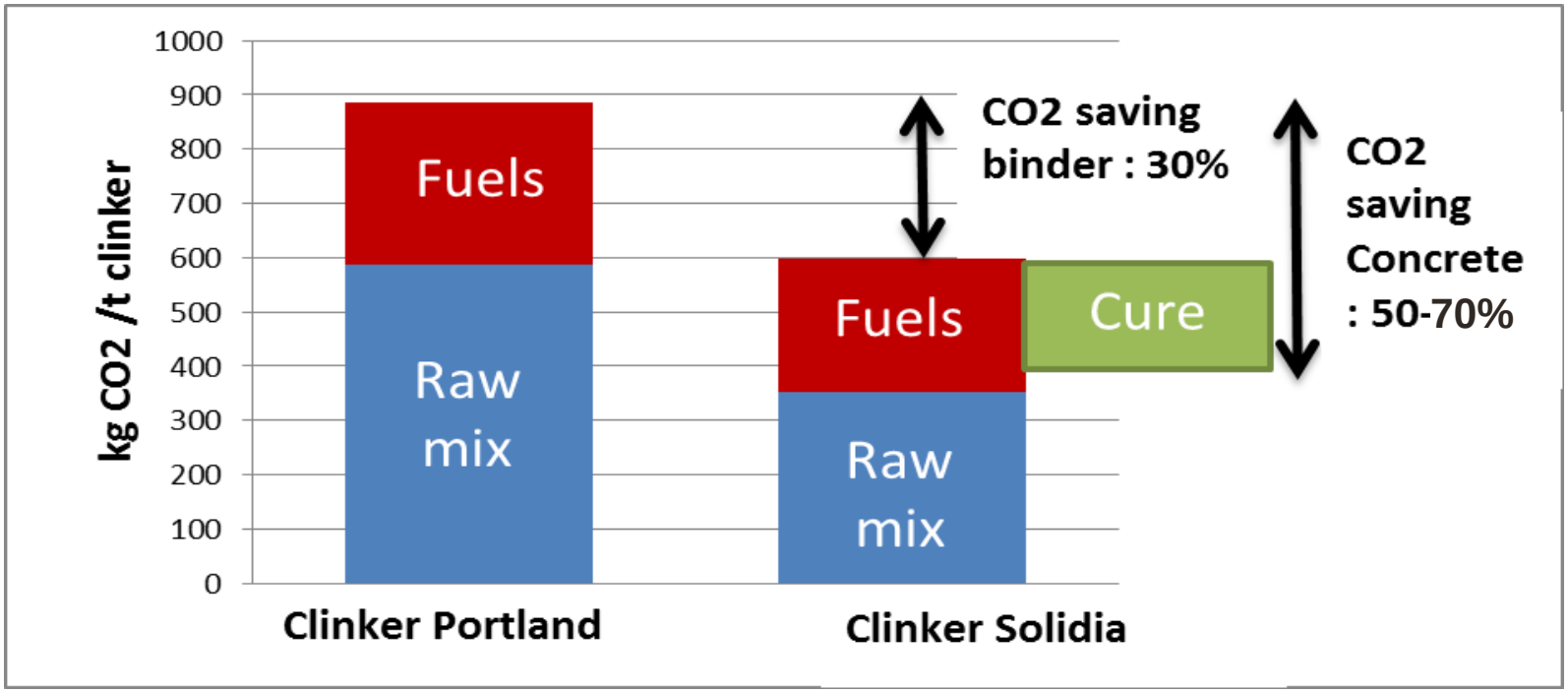
Benefit Summary

Product	▪ Same mix designs ▪ 28-day strength in < 1 Day ▪ Low shrinkage ▪ Light cement colour ▪ Better pigmentation	▪ No $Ca(OH)_2$: ▪ Low efflorescence ▪ …
Process	▪ Same mixing / forming ▪ Rapid cure ▪ Fast clean-up ▪ Reduced concrete waste	▪ Streamlined post-cure processes ▪ Reduced inventory ▪ Extended production season
Sustainability	▪ Up to 70% reduction in CO_2 footprint ▪ Consumes waste CO_2 ▪ Stores as stable calcium carbonate ▪ 80% of process water can be recycled	▪ Local raw materials ▪ Potential carbon credits ▪ Sustainable construction credits

Solidia Technologies solution

Technical solution: CO_2 emissions reductions

- Clinker composition: Wollastonite (CS), Rankinite (C_3S_2) & Belite (C_2S)
  - Different raw mix: Target – 1:1 C/S molar ratio ➔ less limestone used
  - Lower clinkering T°C than for OPC: 1250°C // 1450°C



Solidia Cement

CO_2 Emissions and Sequestration per ton of Clinker

Clinker Type	Limestone Decomposition	Fossil Fuel Combustion	Total CO_2 Emissions	Sequestered CO_2 in Concrete
PC Clinker	540 kg	270 kg	810 kg	-
CSC Clinker	375 kg	190 kg	565 kg	up to 300 kg

- No clinker dilution taken into account for both clinkers
- Grinding energy not taken into account (raw mix and clinker)

Solidia Cement production

Cement production in Whitehall plant (USA)

- Raw materials used available in the quarry:
  - Quarry rock: limestone containing some silica and minor elements (Al_2O_3, Fe_2O_3, MgO, SO_3)
  - Sand: mainly SiO_2
- Fuels used: Petcoke / Coal / Plastics
- 4 stages preheater kiln

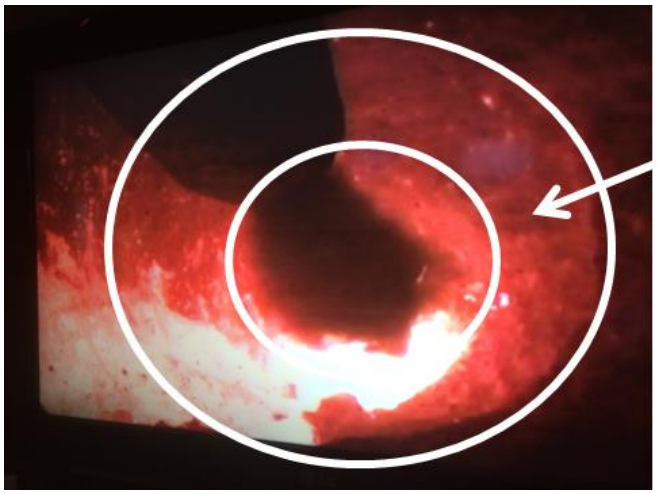
		PC clinker	Solidia Clinker
Period		Normal production	Stable production period
Specific heat consumption (SHC)	GJ/t ck	3.89	3.16
Stack CO_2	%	24.4	14.2
CO_2 emissions	Nm^3/t ck	474	334

30% emissions reductions

Solidia Cement production

Cement production in Whitehall plant (USA)

- Productibility possible improvements:
  - Throughput of the kiln to optimize
  - Different behaviour in the kiln than an OPC clinker
    - New operational conditions to follow
    - Clinkering habits to be adapted and changed
  - Good compromise to be found in between quality and behavior in the kiln
    - Avoid over burning ➔ rings formation
    - Potential kiln stops
  - Grindability equivalent to OPC



Ring formed and gummy material going through

- **Even all these production aspects, this first industrial trial proved 30% CO_2 emissions reduction**

Solidia Concrete

CO_2 footprint reduction due to concrete uptake

- Two applications tested:
  - Pavers
  - Hollow cores

Press machine

Fresh Solidia Concrete

CO_2 curing

Fresh Solidia Concrete
in contact with CO_2 (24h)

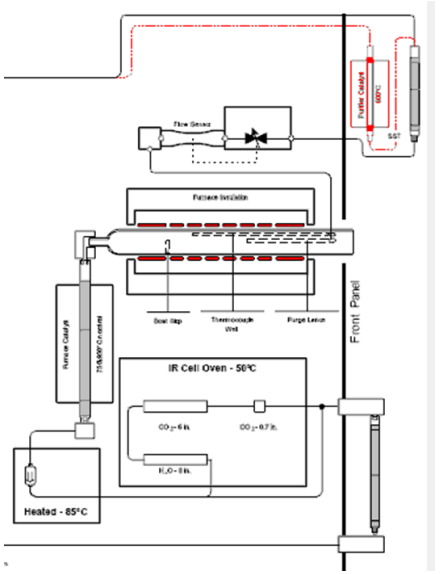
Solidia Concrete

CO_2 footprint reduction due to concrete uptake

- Carbonation efficiency followed by mass gain (CO_2 uptake)

Concrete Product	Mass Gain (CO_2 uptake), %
Paver	3.4
Hollow Core	3.3

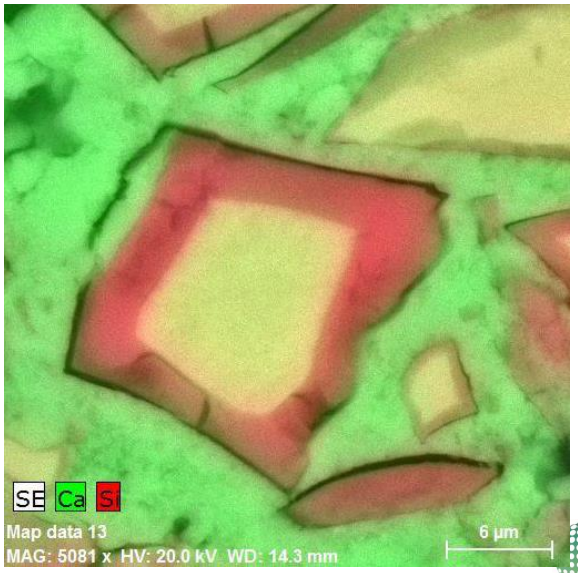
- Lab C and H measurements in a oven coupled to IR cell vs. temperature profile

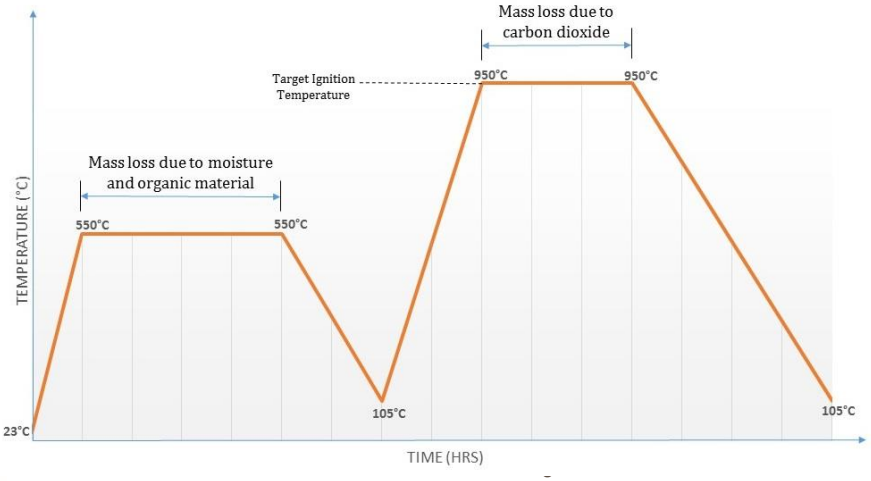


CS = $CaSiO_3$

Si = Silica

Ca = $CaCO_3$





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Solidia Concrete

Total CO_2 savings

Concrete Product	Mass Gain (CO_2 uptake), %	CO_2 Sequestered /t of Cement	CO_2 Savings/t of Cement	Total CO_2 Savings/t of Cement	Total CO_2 Savings, % (vs. 810kg for OPC)
Paver	3.4	236 kg	245 kg	481 kg	**59.4**
Hollow Core	3.3	220 kg	245 kg	465 kg	**57.4**

CO_2 captured in the concrete

CO_2 saved during clinker production

Two applications within the CO_2 savings announced were proved

Solidia Technologies Developments

- **1st industrial pilot (USA): revamping existing chamber**



Typical Run:
- *~8,000 pavers*
- *40 t concrete,*
- *5 t cement*

Pavers quality:
- *Cs > 8000psi = 55 MPa*
- *F/T pass*

- **2nd industrial pilot (UK): New designed chamber**

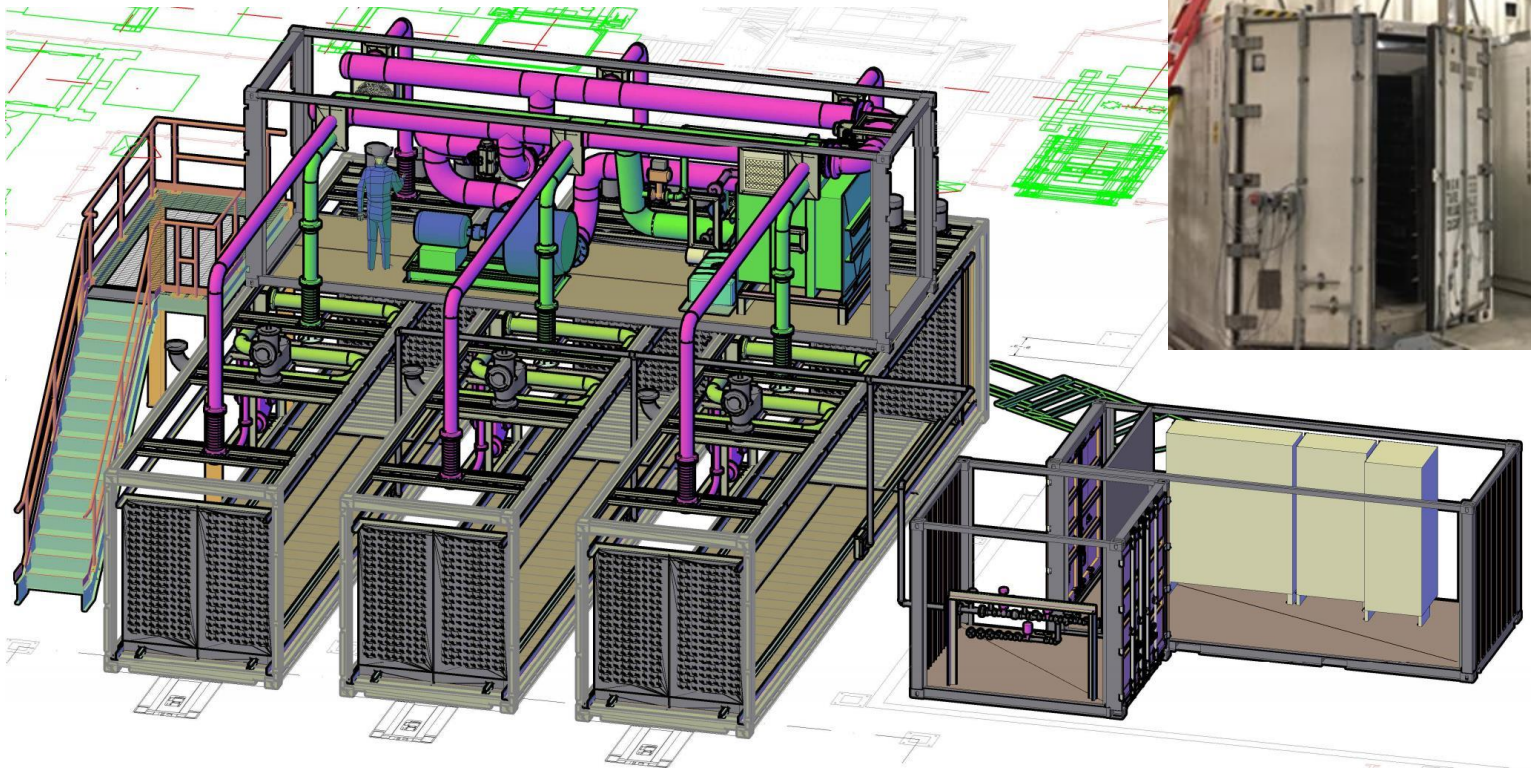



- Equipment commissioning started August 2017
- 20 runs performed

Pavers quality (EN1338):
- Ts > 3.6 MPa
- F/T pass for some runs

Solidia Technologies Developments

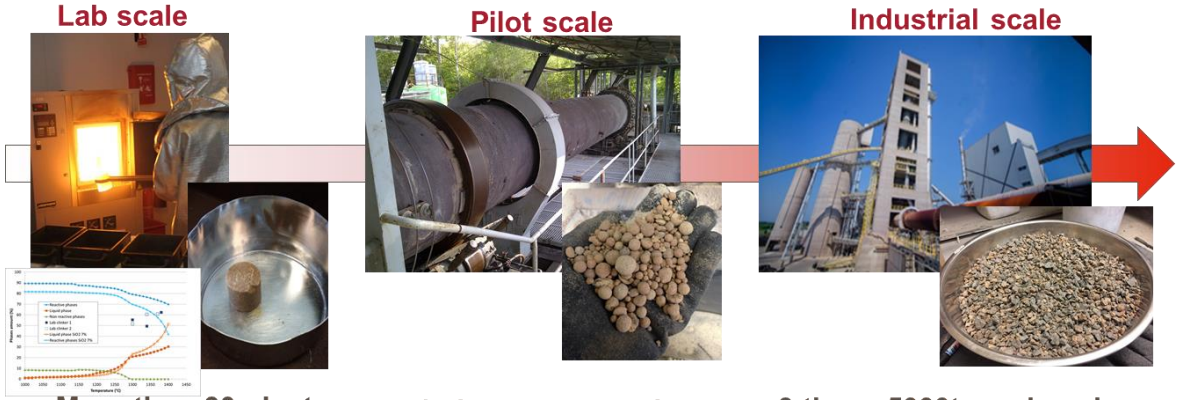
- **A 3rd industrial pilot under commissioning (Canada)**
  - Equipment commissioning started June 2018
  - 4 runs performed already



Conclusions

What has been developed to date?

- ***On the cement side:***



More than 30 plants assessed at lab scale

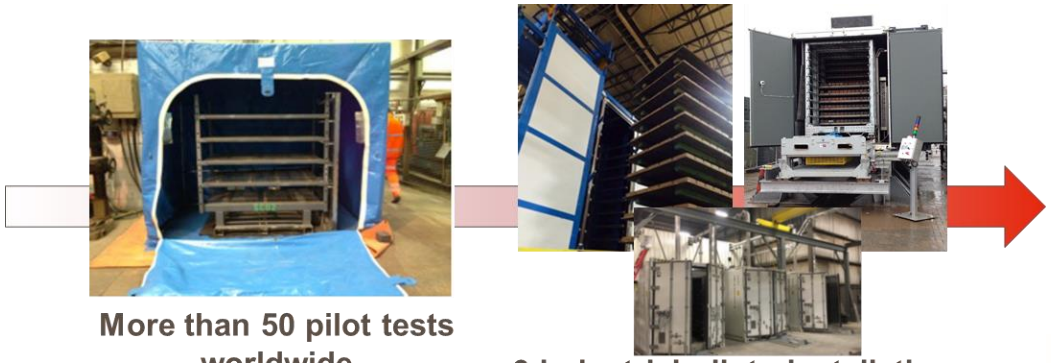
4 plants assessed at pilot scale

3 times 5000t produced worldwide

Durability & Market Acceptance:

- ETA for the cement on-going
- Long-term durability assessment

- ***On the concrete side:***



More than 50 pilot tests worldwide

3 industrial pilots installations

Conclusions: Solidia Technologies business model , a complete integrated solution to precast customers

Solidia Cement footprint
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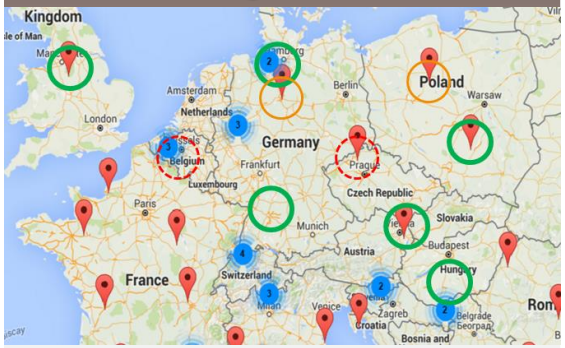

- Raw material quality
- Plant process capability
- Product performance
- Logistic
- Durability
- R&D

Solidia technology
Solidia Technologies

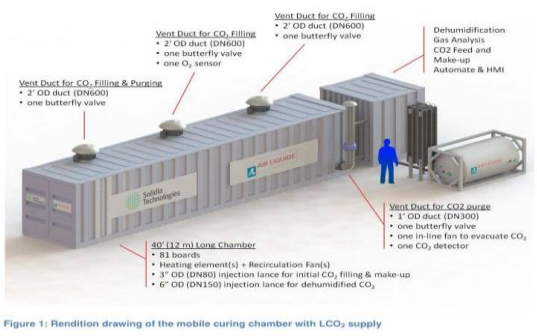

Figure 1: Rendition drawing of the mobile curing chamber with LCO_2 supply

- Raw material selection
- Mix Design
- Testing
- Curing process
- Durability

CO_2 management
Air Liquide

- CO_2 capture
- CO_2 sourcing and supply
- Equipment design

Integrated offer from LH

Precast customers

Thank you for your attention, Questions?

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www.solidlife.eu

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