Solidia’s approach on CO₂ Emission Reduction in Pre-Cast and Ready Mix Concrete

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Bangkok, Thailand
Venue: Virtually via MS Teams from UN ESCAP
20 April 2021
The cement industry...

- Produces ~ 3 Gt of OPC clinker per year
- Emits ~ 2.5 Gt of CO₂

0.815 t of CO₂ emitted for every tonne of OPC clinker produced
Solidia Cement in Pre-cast Concrete
Solidia Cement
Novel cement chemistry, reduced CO₂ emissions at kiln

- **Simple, low-lime chemistry**
  - 30% reduction in process CO₂

- **Synthesized at low temperature**
  - 30% reduction in thermal CO₂

- **Reduced fuel cost**

- **Manufactured in N.A. and Europe**

<table>
<thead>
<tr>
<th>CO₂ Emitted (per t clinker)</th>
<th>Portland Cement</th>
<th>Solidia Cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process CO₂</td>
<td>0.545 t</td>
<td>0.375 t</td>
</tr>
<tr>
<td>Thermal CO₂</td>
<td>0.270 t</td>
<td>0.190 t</td>
</tr>
<tr>
<td>Total</td>
<td>0.815 t</td>
<td>0.565 t</td>
</tr>
</tbody>
</table>

Reduction of 0.25 t of CO₂ emitted per t of cement produced.
Solidia Cement in Precast Concrete
Easily reacted with CO₂ to further reduce CO₂ footprint

\[ \text{CaSiO}_3 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{SiO}_2 \]

- Captures ~240 kg per t cement

\[ \text{H}_2\text{O} \]

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<th>CO₂ Footprint (per t cement)</th>
<th>Portland Cement</th>
<th>Solidia Cement</th>
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<tr>
<td>Kiln Emissions</td>
<td>0.815 t</td>
<td>0.565 t</td>
</tr>
<tr>
<td>CO₂ Utilized in Reaction</td>
<td>n/a</td>
<td>-0.240 t</td>
</tr>
<tr>
<td>CO₂ Penalty *</td>
<td>n/a</td>
<td>0.05 t</td>
</tr>
<tr>
<td>Total</td>
<td>0.815 t</td>
<td>0.375 t</td>
</tr>
</tbody>
</table>

Reduction of 0.44 t of CO₂ per t of cement used

* CO₂ equivalent of energy for capture, purification and delivery of CO₂
Solidia Cement in Precast Concrete
Significant market, CO\textsubscript{2} impact

In Market Today
- Paver/block mfgs. in N.A. & Europe
- Demonstrated cost / performance advantages
- Manageable code requirements
- Fast adoption

Precast CO\textsubscript{2} Impact
- Precast = 30% of concrete market
  = 0.9 Gt of OPC
- 100% OPC replacement
- CO\textsubscript{2} Savings = 0.44 t per t of cement

Solidia Precast
0.4 Gt CO\textsubscript{2}

Solidia Concrete from EP Henry for stormwater management
Elsmere Fire Company, Elsmere, DE
Solidia Cement in Ready-Mix Concrete
Solidia SCM in Ready-Mix Concrete
Carbonate Solidia Cement to make synthetic Pozzolan

Solidia SCM = Solidia Cement Reacted with CO₂ at the Cement Plant

CaSiO₃ + CO₂ + H₂O → CaCO₃ + SiO₂

Solidia Cement is composed of:
• Crystalline calcium silicates
• Crystalline mellilitie
• Amorphous calcium alumino silicate

Raw Solidia Cement

Solidia SCM in Ready-Mix Concrete
Carbonate Solidia Cement to make synthetic Pozzolan

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Solidia Cement is composed of:
• Crystalline calcium silicates
• Crystalline mellilitie
• Amorphous calcium alumino silicate
Solidia Cement in Ready-Mix Concrete
Amorphous silica imparts pozzolanic properties

- Blended with Portland cement
- Reacts with Ca(OH)$_2$ from PC hydration
- Synthetic fly-ash, slag replacement

SiO$_2$ + Ca(OH)$_2$ + H$_2$O $\rightarrow$ CaO-SiO$_2$-H$_2$O (C-S-H gel)

3CaO.Al$_2$O$_3$ + CaCO$_3$ + H$_2$O $\rightarrow$ 3CaO.Al$_2$O$_3$.CaCO$_3$.11H$_2$O

- Two types of SCMs make up 2/3 of the market:
  - Blast Furnace Slag (from steel production)
  - Fly Ash (from coal production)

- SCMs currently make up ~25% of the total cement sold globally and demand is increasing, supply is decreasing.

Solidia Concrete Ready-Mix
Piscataway, NJ
### Solidia SCM in Ready-Mix Concrete

Easily reacted with CO₂ to further reduce CO₂ footprint

<table>
<thead>
<tr>
<th>% Replacement Level</th>
<th>CO₂ emitted per tonne (kg)</th>
<th>CO₂ saved per tonne (kg)</th>
<th>CO₂ saved (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% OPC Clinker</td>
<td>815</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>80% OPC – 20% Solidia SCM</td>
<td>705</td>
<td>110</td>
<td>~13.5</td>
</tr>
<tr>
<td>65% OPC – 35% Solidia SCM</td>
<td>622</td>
<td>194</td>
<td>~24</td>
</tr>
<tr>
<td>50% OPC – 50% Solidia SCM</td>
<td>539</td>
<td>277</td>
<td>~34</td>
</tr>
</tbody>
</table>

- Production of 1 ton of Solidia SCM emits ~ 262 kg of CO₂
- Turns 0.2-0.24 tons of waste gas into solid product per ton of clinker
- Increases throughput at the cement plant by 35%
- Guarantees consistent quality and supply
Solidia Cement in Ready-Mix Concrete

Significant market, CO$_2$ impact

Next Product to Market

- Being Tested at Certified Third Party Testing Labs and in Academia
  - Strength reactivity index
  - Strength development
  - Water demand, flow
  - ASR mitigation

Ready-Mix CO$_2$ Impact

- Ready-Mix = 70% of concrete market
  = 2.1 Gt of OPC
- 35% OPC replacement
- CO$_2$ Savings = 0.55 t per t of cement

\[
\text{Solidia Precast} + \text{Solidia Ready-Mix} = \text{Total Impact}
\]

\[
0.4 \text{ Gt CO}_2 + 0.4 \text{ Gt CO}_2 = 0.8 \text{ Gt CO}_2
\]
Explanation of CO$_2$ Savings Calculation

Calculation basis:

- 1 Ton of OPC clinker emits 816 kg of CO$_2$
- 1 Ton of Solidia Clinker emits 565 kg of CO$_2$
- 1 ton of Solidia Cement will Consume 200-250 kg CO$_2$ upon carbonation (Assume 240 kg for calculations)
- 1.24 tons of Solida SCM will form upon carbonation of 1 ton Solidia Cement
- CO$_2$ footprint of 1.24 tons of Solidia SCM is 565-240 = 325 kg. \(\rightarrow\) CO$_2$ footprint of 1 ton of Solidia SCM is 325/1.24 = 262 kg
- % CO$_2$ Savings general formula:
  \[
  100 - \left[816 \times (1 - \text{replacement level}) + (262 \times \text{replacement level})\right] \times \left(100/816\right)
  \]

Example: At 35% replacement

- Emissions from OPC = 816x0.65= 530 kg
- Emissions from Solidia SCM = 262x0.35 = 91.7 kg;
- Total CO$_2$ emissions of the mix = 530+91.7 = 621.7 kg; 23.8% Savings
OPC Production vs Solidia SCM Production

~35% increase in Product Mass

1 ton of raw material produces:

- 0.65 t of OPC clinker

12% increase

- 0.73 t of Solidia clinker

~35% increase

- 0.87 t of Solidia SCM