New \(\text{CO}_2\) – curing Technology for Concrete

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Advancing the Cement Industry’s Carbon Reduction Goals
Concrete is the most widely used material in the world after water. Cement is used to bind concrete together, giving it the requisite strength and durability for a wide variety of applications around the world. Cement production, however, is the second largest emitter of carbon dioxide (\(\text{CO}_2\)) in the world, responsible for three to five percent of total global carbon emissions. Six of the top 10 traders in carbon credits in Europe are cement companies. Cement manufacturers have committed to reducing their carbon footprint but are often constrained by their assets and chemistry.

US start-up Solidia Technologies\(^*\) (solidiatech.com) has joined forces with The Linde Group (linde.com) to industrialize an innovative technology that could reduce the environmental footprint of cement in precast concrete applications while reducing concrete production costs and improving the performance of concrete-based building materials. The collaboration includes the development, demonstration, and commercialization of Solidia’s \(\text{CO}_2\)-based concrete curing technology. The two companies also are collaborating on marketing the technology as a new solution for the pre-cast concrete sector.

Solidia is bringing a sustainable innovation to a market that dates back 2,000 years and whose last major product innovation was the development of Portland cement in the early nineteenth century. Solidia is tasked not only with the development of sustainable technologies, but making those technologies easy for the industry to adopt.

By developing a means of transforming \(\text{CO}_2\) into a valuable commodity for one of the world’s largest industries, the Linde-Solidia collaboration will help speed the market penetration and social impact, re-categorizing \(\text{CO}_2\) as a catalyst for profitability and growth.

Novel \(\text{CO}_2\)-curing Technology
Solidia’s \(\text{CO}_2\)-based concrete curing technology utilizes Solidia Cement\(^*\), a novel chemistry developed by Solidia. The patented technology allows lower \(\text{CO}_2\) emissions in the cement production process and involves the use of \(\text{CO}_2\) as a curing agent in pre-cast concrete manufacturing. The curing process of concrete made using Solidia Cement sequesters up to 300 kg of \(\text{CO}_2\) per tonne of cement. Overall, \(\text{CO}_2\) emissions associated with the production and use of cement can be reduced by up to 70 percent. Benefits realized by the concrete industry include reduced materials and water usage, shorter curing times, and improved product durability.

Solidia Concrete can be produced by manufacturers of traditional concretes and can be designed to address any pre-cast concrete application. These products, which include paving stones, concrete blocks, hollow-core slabs, railroad sleepers (ties), roof tiles, and pervious concrete, match or exceed the properties and characteristics of concrete products made using ordinary Portland cement (OPC). Additionally, the Solidia Concrete cures in less than 24 hours, compared to the up to 28 days required for traditional concrete products to reach full strength. As water is not consumed during the \(\text{CO}_2\)-curing process, it can be collected and reused, with recycle rates of 60 to 80 percent.

Delivering and Managing \(\text{CO}_2\)
A critical development along the path to commercializing Solidia’s concrete technology will be delivering \(\text{CO}_2\) to the concrete curing location and managing it at that location. Supply of \(\text{CO}_2\) will be first for in-plant pre-cast and eventually for on-site cast-in-place construction. Linde will bring \(\text{CO}_2\) supply and delivery expertise, including engineering of application-specific equipment, to contribute to this joint development. With its impressive \(\text{CO}_2\) supply infrastructure using trucks, railcars, and ships for \(\text{CO}_2\) transport, its experience with \(\text{CO}_2\) production and its wide range of applications-specific knowledge, Linde is well prepared to support the roll-out of this technology. This project marks an important step in expanding Linde’s \(\text{CO}_2\) supply and management capabilities.

As collaborators with a global reach and decades of technological and market knowledge, industry leaders such as Linde play a significant role in driving innovation to market. Linde’s expertise in gas delivery and equipment engineering enables rapid commercialization by freeing Solidia to focus on the development of the core technology. Likewise, Solidia’s technology gives Linde access to a large, new market for \(\text{CO}_2\) that would not otherwise exist.

Developing \(\text{CO}_2\)-curing Chamber Technology
Solidia also recently signed a partnership agreement with CDS Group (cds-group.co.uk), the world’s largest supplier of pre-cast concrete curing and drying equipment, to collaborate on the design of systems and components needed to cure concrete with \(\text{CO}_2\) instead of water. The innovations will include technological upgrades for existing curing chambers and the design and manufacture of new curing chambers to accommodate Solidia’s patented \(\text{CO}_2\)-curing process.

CDS will play a key role helping Solidia achieve its top R&D priority, which is to make it easy and profitable for concrete manufacturers to adopt its novel technology. Modifying existing chambers will minimize capital investment for Solidia’s customers. Because CDS is marketed worldwide, CDS is fully conversant with the regulations that occur in countries across the globe and can provide systems that have technical and regulatory approval.

Public and Private Sector Collaborators
Solidia has purposefully sought partnerships with private sector leaders committed to the commercialization of sustainable technologies and with public sector organizations capable of validating technologies.
Solidia Cement™ is poured and vibrated in molds to achieve concrete consolidation. The sleepers are then loaded onto the curing system base.

The CO2 curing system is sealed.

Solidia Concrete™ RR sleeper after CO2-curing.

and accelerating their adoption. The Linde and CDS collaborations, described above, are examples of the former.

Also in this group is Lafarge (lafarge.com), a world leader in cement, concrete, and building materials technology. Like Linde and CDS, Lafarge places innovation at the heart of its priorities in order to contribute to more sustainable construction. Since 2010, the company has been part of the Dow Jones Sustainability World Index.

Lafarge signed a partnership agreement with Solidia in 2013 and recently joined Solidia as an investor with a seat on its board of directors. In the first half of 2014, Lafarge and Solidia successfully conducted a trial to demonstrate feasibility of commercial-scale cement production. The two companies are actively collaborating to market this technology as a new solution for the pre-cast sector.

An impressive array of public sector organizations have joined Solidia in the quest to characterize and commercialize its sustainable technology. Prominent among these is the US Department of Energy’s National Energy Technology Laboratory (DOE-NETL). To date, an ongoing research project has been funded with $1.1 million from the DOE-NETL through its Carbon Storage Technology program and $1 million from Solidia Technologies as a cost share. DOE-NETL supports Solidia Cement-based concrete technology because of its potential to consume CO2 as it cures.

The project has focused on developing an understanding of the relationships between the water use, CO2-curing time, and mechanical strength of Solidia Cement-based concrete. The research has demonstrated that Solidia Concrete can achieve full hardness in less time than traditional OPC-based concrete. In every application studied, Solidia Concrete cures in less than 24 hours. In addition, at every stage of curing, Solidia Concrete parts match or exceed the strength of comparable products made with OPC-based concrete.

DOE-NETL recently agreed to finance the project’s next stage, which will focus on demonstrating this CO2 reduction and storage capability on a prototype scale in a commercial concrete plant.

Other collaborators include the US Department of Transportation’s Federal Highway Administration (USDOT-FHWA), Purdue University, The University of South Florida, Rutgers, and the State University of New Jersey.

USDOT-FHWA supports Solidia through a Cooperative Research and Development Agreement. This agreement governs a program conducted at the Turner-Fairbank Highway Research Center where the mechanical, chemical, and environmental durability of Solidia Concrete has been systematically examined and confirmed vis-à-vis transportation infrastructure applications.

Research programs at Purdue University and the University of South Florida also focus on the durability of Solidia Concrete. Purdue has characterized the behavior of Solidia Concrete in freeze-thaw, in freeze-thaw with de-icing salts, and in sulfate environments. South Florida is assessing the corrosion of rebar and the overall performance of reinforced Solidia Concrete in a variety of simulated service conditions.

Long-term research at Rutgers, where the original generation of the Solidia Concrete technology was developed, continues to focus on the optimization of the CO2-curing process.

Conclusion

The Cement Sustainability Initiative of the World Business Council for Sustainable Development set 2050 CO2 reduction targets for the global cement industry. Hypothetically, if the industry were to adopt Solidia’s technologies today, it could achieve those 2050 goals within three years.

The partnerships between Solidia, Linde, CDS, Lafarge, US government agencies, and university laboratories marry the scientific innovation of a start-up with the market intelligence and global infrastructure of established industry leaders, and the expertise, facilities, and funding available in the public and academic sectors. Together, they create a sustainable pathway for the cement and concrete industry with the development of new technologies that offer cost savings and added value without burdening the industry with significant capital investments or dramatic changes in production.

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