June 29, 2023

The California Air Resources Board
1001 I Street
Sacramento, CA 95814

RE: Comments on Second Workshop for SB 596 Cement Sector Net-Zero Emissions Strategy

Thank you for the opportunity to comment on the Second Workshop for SB 596 Cement Sector Net-Zero Emissions Strategy. We applaud CARB for being a national leader in addressing climate change, and when you are developing your strategy, we encourage you to consider the benefits of cements and concretes that utilize CO_2 in the production of final products. Our company has developed materials used in concrete production that react with carbon dioxide and permanently mineralize the carbon. These technologies offer the cement industry an alternative to carbon capture through sequestration and geological impoundment by providing options for converting permanently bound carbon into value-generating products aligned with a circular economy approach to sustainability.

About Solidia Technologies

Solidia is a cement and concrete technology company, offering patented low carbon solutions that make it easy and profitable to use carbon dioxide (CO_2) to create superior, sustainable building materials. Solidia provides three core technologies that would each dramatically reduce carbon emission from cement and concrete production:

A. Solidia Cement®

Solidia has commercialized the production of a non-hydraulic, low-lime cement that gains strength through a carbonation process. Solidia Cement is prepared using the same raw materials and industrial processing equipment as Portland Cement but realizes a significant reduction in both:

a) process CO_2 (from limestone decomposition) since it uses less limestone; and
b) thermal CO_2 (from fossil fuel consumption) because Solidia Cement can be produced at lower temperatures.

This translates to a 30% reduction in CO_2 emissions at the kiln during production when compared to Portland Cement. Notably, production of Solidia Cement does not require re-equipping existing cement facilities.

There are several additional advantages of Solidia Cement worth noting:

First, because of the high heat needed to produce Portland Cement, facilities are largely unable to adopt greener sources of energy to power their kilns. Since Solidia Cement lowers the temperature required in the production process, it opens the door for the use of cleaner energy sources. This important technological breakthrough can not only reduce demand for CO_2-emitting fuels but can also increase demand for renewable energy – all of which helps support the state's broader net-zero efforts.

Second, although some cement and concrete production facilities are pursuing CO_2 capture technologies to reduce their emissions, many lack CO_2 storage and utilization options. This can be due to geography

and other factors.[1] Solidia Cement — since it absorbs CO_2 to produce Solidia Concrete™ and Solidia SCM™ — can provide those much-needed storage and utilization options for both cement plants and other large industrial CO_2 emitters. This technology can help provide a market for existing CO_2 capture technologies that are in need of new markets that can utilize captured CO_2.

B. Solidia Concrete

Solidia Concrete is made by reacting Solidia Cement with CO_2 according to the basic chemical reaction:

- $CaSiO_3 + CO_2 \xrightarrow{H_2O} CaCO_3 + SiO_2$

In this reaction, the CO_2 is permanently consumed while making the concrete into a solid, durable, and valuable product. Each metric ton (MT) of Solidia Cement that is used in the precast concrete formulation will utilize and store at least 0.2 MT of CO_2. This is an addition to the 30% emissions reduction achieved in Solidia Cement production. Overall, the embodied greenhouse gas emissions reductions for precast concrete products can be greater than 50%. Precast concrete products include paver stones, concrete blocks, and box culverts.

Since Solidia Concrete is cured with CO_2 instead of water, production of Solidia Concrete also consumes dramatically less water than production of incumbent concrete with Portland Cement.

Solidia Concrete can be produced in existing precast concrete facilities when re-equipped to handle CO_2 enclosure while the CO_2 is being utilized. Notably, Solidia Concrete is already available for commercial use in precast concrete plants.

C. Solidia SCM

Supplementary cementitious materials (SCMs) are commonly added to concrete to make concrete mixtures more economical, reduce permeability, increase strength, or influence other concrete properties. Typical examples are fly ash, slag cement, and silica fume. The addition of alternative SCMs is one of the most cost-effective and immediately available options to supply additional US demand and simultaneously lower the cement industry's CO_2 footprint. However, the supply of traditional SCMs is in decline, requiring the U.S. to rely more heavily on imports. Fly ash, for example, is produced from coal-fired power plants, an energy source that is being phased out across the U.S.

With Solidia SCM, our company can help narrow the SCM supply gap. Solidia SCM is an engineered SCM that can be used to partially replace Portland Cement when used in concrete. As with the use of Solidia Cement and CO_2 in the production of Solidia Concrete, Solidia SCM is produced by carbonating Solidia Cement. The resulting product can be used at high replacement rates as a superior performing SCM with over 50% less greenhouse gas emissions than the Portland Cement it replaces.

Solidia SCM can be produced at existing cement production facilities when re-equipped to capture CO_2 that is emitted from the cement production process and utilize that same CO_2 to convert Solidia Cement to Solidia SCM. The mineralization of CO_2 in Solidia SCM opens the door for CO_2 capture directly from the

[1] "Industrial Decarbonization Roadmap." Department of Energy, 2022, p. 147, https://www.energy.gov/sites/default/files/2022-09/Industrial%20Decarbonization%20Roadmap.pdf.

flue gas stream of an operating cement plant, and conversion to a marketable product on-site in a single reaction step.

Solidia SCM can also be produced alongside industrial plants with large CO_2 emissions and capture facilities to mineralize CO_2 more efficiently at the point of capture. This not only offers CO_2 utilization options for non-cement facilities, but also expands the options for where Solidia SCM can be produced. Importantly, this could provide an avenue for carbon utilization for industries in geographic areas where carbon capture and storage are cost prohibitive.

Department of Energy (DOE) publications have noted the importance of CO_2 utilization in cement and concrete production

The DOE's "Industrial Decarbonization Roadmap" identifies carbon utilization as a major opportunity for cement producers.[2] In addition, a table in the DOE's recent "Pathways to Commercial Liftoff: Carbon Management" included the following list of utilization opportunities:[3]

Utilization Case	Key technologies
1 Building materials	• **CO_2-cured cement**: injects CO_2 into fresh ready-mix cement or in pre-cast concrete • **CO_2-based aggregates**: metal oxides are extracted and carbonated using CO_2 from flue gas, and deposited onto a substrate creating aggregate that is composed of carbonates • **Clinker replacement:** substitution of limestone with alkaline materials like fly ash followed by carbonation with CO_2

Relevance of Mineralization to the SB 596 Cement Sector Net-Zero Emissions Strategy

In developing the comprehensive strategy and defining metrics for greenhouse gas intensity, the following sections of SB 596 are directly relevant to recognizing and incentivizing the benefits of mineralization:

> Section 1 (a) (6) Implementing complementary strategies to both reduce the greenhouse gas intensity of cement production and grow the demand for low-carbon concrete will also reduce air pollution and improve public health in California communities.
>
> > Recommendation: The definition of low-carbon concrete should include the benefit of CO_2 mineralization.
>
> Section 2 (a) (3) When determining the greenhouse gas intensity of cement, the state board shall not include greenhouse gas emissions reductions attributable to activities or offsets that are unrelated to the raw materials, fuels or other energy sources, processes, or transportation involved in making or using cement or using cement or its inputs.
>
> > Recommendation: The definition of greenhouse gas intensity of cement should include CO_2 mineralizing processes involved in using cement.

[2] *Id*. at 150.
[3] "Pathways to Commercial Liftoff: Carbon Management." Department of Energy, 2023, p 18, https://liftoff.energy.gov/wp-content/uploads/2023/04/20230424-Liftoff-Carbon-Management-vPUB_update.pdf

Section 2 (b) (7) (A) Measures to expedite the adoption for use in projects undertaken by state agencies, including the Department of Transportation, of Portland limestone cement and other blended cements.

Recommendation: The adoption measures should include blended cements that incorporate materials with mineralized CO_2.

Thank you for your consideration of these comments.

Sincerely,

Russell Hill

Russell Hill
Chief Executive Officer
Solidia Technologies, Inc.