Innovation Shared at the ACI Foundation 2024 Technology Forum, Part 2

For over 25 years, the ACI Foundation has hosted Technology Forums to support ACI's expanding focus on advancing the concrete industry. These gatherings are innovation-focused educational and networking events featuring presentations by researchers, ACI committee representatives, and developers of new technologies for design, construction, and inspection. This article is the second of a series of three that summarizes the presentations made at the 2024 Technology Forum.

Innovations that have a broad impact on the industry are often built into a panel discussion with extended time for questions and answers with attendees. At the 2024 Technology Forum, the topic of low-carbon concrete materials was presented in this manner. Five quick-fire presentations were given by technology owners on various low-carbon offerings. After extended discussion, the segment ended with a presentation outlining ACI's new low-carbon concrete code. These Forum presentations can be downloaded at **https://www.acifoundation.org/portals/12/Files/CIC/2024-Technology-Forum-Presentations.zip**.

Fortera

Presented by Craig W. Hargis, Vice President, Technical Services, Fortera

Fortera is a pioneering green cement manufacturer focused on decarbonizing cement in collaboration with cement manufacturers. Its ReCarb® process mineralizes industrial carbon dioxide (CO_2) to produce cementitious materials with 70% less CO_2 emissions than portland cement. The technology bolts onto existing cement manufacturing plants, pulling industrial CO_2 from the flue stack of a cement kiln and capturing it without any need for compression or purification. The mineralized CO_2 can be used to produce blended cement, or it can be used as the sole binder in concrete. The process steps include calcining limestone to produce lime, dissolving the lime in a proprietary solvent, and bubbling CO_2 through the solution (Fig. 1). Reactive calcium carbonate (vaterite) is produced as a precipitate that is filtered, dried, and thermally polished before shipment for concrete production.

C-Crete Technologies

Presented by Rouzbeh Savary, President, C-Crete Technologies

C-Crete has pioneered a concrete binder that is essentially free of CO_2 emissions. Concrete produced using the C-Crete binder exceeds portland cement concrete in performance. It requires less water, is flowable, sets like conventional concrete, and reaches a strength of more than 7000 psi (48 MPa). Further, the binder meets or exceeds industry standards such as ASTM C1157/C1157M (refer to Table 1) and has cost parity with conventional cement. So far, more than 2500 tons (2270 tonnes) of C-Crete products have

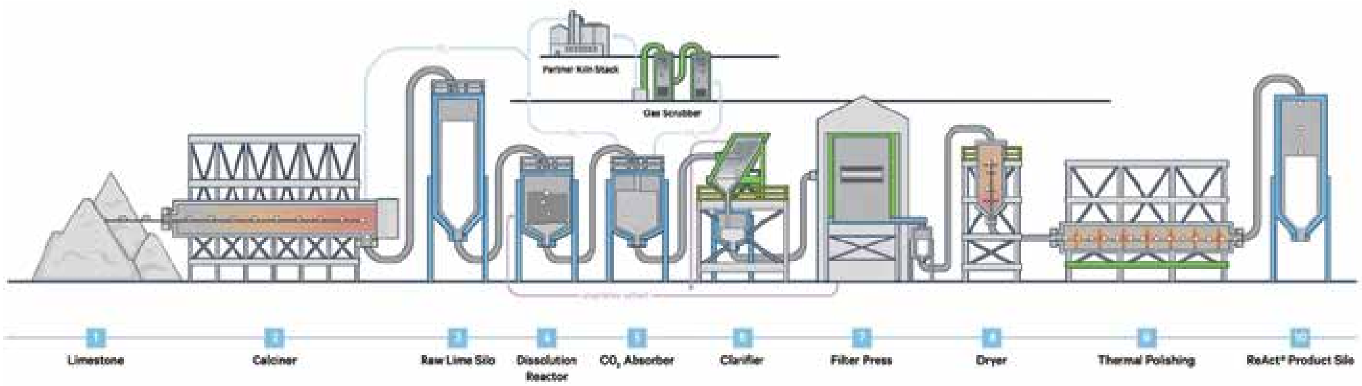


Fig. 1: Fortera's process produces reactive calcium carbonate by dissolving lime in a proprietary solvent, bubbling CO_2 through the solution, and processing the resulting precipitate

Table 1:
The C-Crete binder has been shown to comply with the requirements of ASTM C1157/C1157M, "Standard Performance Specification for Hydraulic Cement"

Property	Time	ASTM test	C-Crete results	Min. or max. per standard	Unit
Compressive strength	3 days	C109/C109M	5000	>1800	psi
	7 days		6200	>2900	psi
	28 days		8000	>4060	psi
Mortar bar expansion	14 days	C1038/C1038M	0.012	<0.02	%
Time of setting, Vicat test		C191	165	45 < Setting < 420	minutes
Air content		C185	1.7	<12	%
Autoclave length change		C151/C151M	0.21	<0.8	%
Alkali-silica reaction	14 days	C1260	0.01	0.02	%
	56 days		0.02	0.06	%

Note: 1000 psi = 6.9 MPa

already been placed in foundations, shear walls, columns, floors, slabs-on-deck, driveways, and steps of various projects; and more projects are currently underway. Binders have been produced using basalt, zeolite, granite, and slag as raw materials, and binders based on additional materials are in development.

Terra CO2

Presented by Michele Blackburn, Commercial Director, Terra CO2

Terra CO2 technology uses widely available silicate-based raw materials that are among the most abundant materials on Earth. The company's plants are being located on or near existing aggregate mine sites, thereby minimizing transportation costs and leveraging existing infrastructure. Feedstocks include silicates such as basalt, slate, shale, and mine tailings. These materials are milled and vitrified into a glassy powder that is a supplementary cementitious material, OPUS SCM (Fig. 2), which is suitable for direct replacement of Class F fly ash in concrete. To reach scale, Terra CO2 has developed an advanced processing facility (APF) that currently produces OPUS SCM and in the future will produce a full cement replacement, OPUS ZERO™, a nonhydraulic binder. If manufactured using renewable energy, OPUS ZERO production will cause zero CO_2 emissions. Terra CO2 is breaking ground on its first APF facility in early 2025. The plant will be located in the Dallas-Fort Worth, TX, USA market.

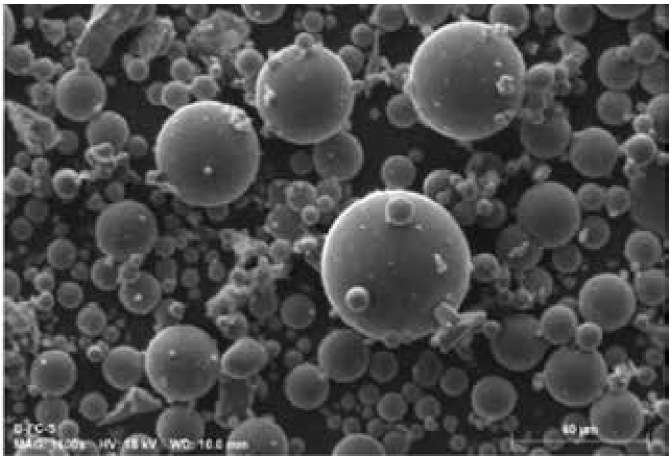


Fig. 2: The Terra CO2 process is based on vitrification of silicates. The company is currently producing a glassy, microspherical pozzolanic supplementary cementitious material and is developing a nonhydraulic binder

Prometheus Materials

Presented by Loren Burnett, President and CEO, Prometheus Materials

Prometheus Materials is currently producing a carbon-negative cement and concrete. This is accomplished by sequestering carbon during manufacturing and avoiding the carbon-heavy processes associated with cement production. The company's ProZero™ supplemental blend is a 1:1 replacement of ordinary portland cement (OPC) (Fig. 3). This blend is mixed with aggregate and OPC and as a result yields up to 166% reduction in global warming potential (GWP). Microalgae are the key. The company is manufacturing its product at its pilot facility using algae growing in photobioreactors. As the company moves toward global distribution, they will work with partners to grow algae in outdoor raceway ponds. In the company's patent-pending process, the microalgae are grown using sunlight, nutrients (nitrogen, phosphorus, and potassium), water, and CO_2; and they are stimulated to produce biomineralized calcium carbonate. Water is evaporated from the calcium carbonate and algal materials, which are then combined with proprietary binding agents. The resulting powder is shipped to producers of cement, concrete, and manufactured concrete products for production and distribution. The process can use recycled, nonpotable water; and virtually all the water used in the production process is returned to the environment.

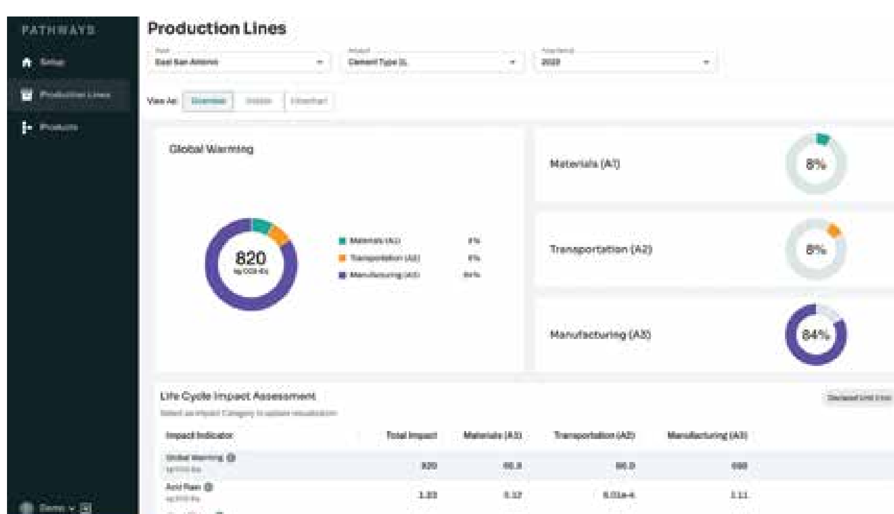
Fig. 3: Prometheus Materials' ProZero blend can be used in a variety of products

Pathways

Presented by Dorian Krausz, Founding Carbon Lead, Pathways

Pathways' artificial intelligence (AI)-powered platform ingests and transforms unstructured data, performs ISO- and EN-compliant life-cycle assessments (LCAs), oversees independent third-party verification, and automatically publishes product-specific environmental product declarations (EPDs) without manual data collection (Fig. 4). Visibility into this real-time data layer allows manufacturers to understand the environmental impacts of their processes, identify emission hotspots, and unlock decarbonization strategies. They can therefore effectively reduce the environmental impacts of new construction and comply with demands from building owners, certification systems, and regulations governing embodied carbon.

(a)



(b)

Fig. 4: Pathways works with manufacturers to create product LCAs and EPDs: (a) using an environmental digital twin of the production line process for a given material, the Pathways system ingests unstructured data; and (b) the system's dashboard allows the manufacturer to identify hot spots in its processes and to make side-by-side comparisons of multiple facilities within their portfolios

Innovative Solutions for Adoption of Low-Carbon Concrete in Codes

Presented by Matthew P. Adams, Associate Professor, New Jersey Institute of Technology

Adams discussed how governments and industry have defined low-carbon concrete, how policy affects implementation (Fig. 5), and what innovators must do to enter the market for low-carbon concrete. Experience has shown that successful policies have the following features:

- Technology agnosticism;
- Community stakeholders engagement;
- Leadership in both policy development and implementation;
- Community involvement and collaboration with contractors to transfer knowledge;
- Owner risk absorption willingness; and
- Cost offset potential.

Generally, low-carbon concrete is

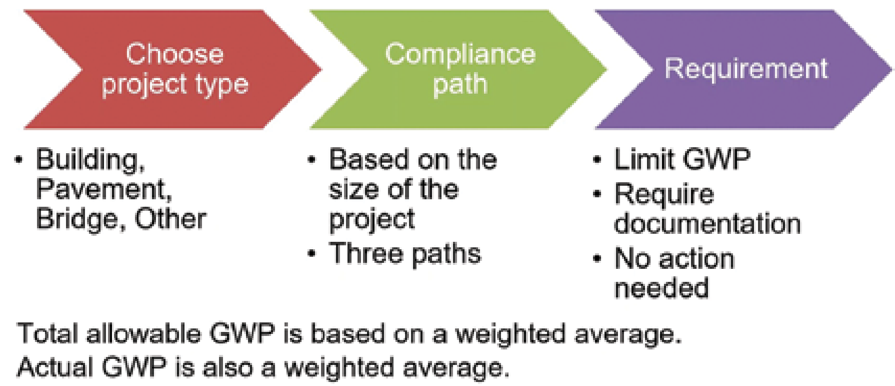


Fig. 5: "Low-Carbon Concrete—Code Requirements and Commentary (ACI CODE-323-24)" defines three compliance paths based on the project size

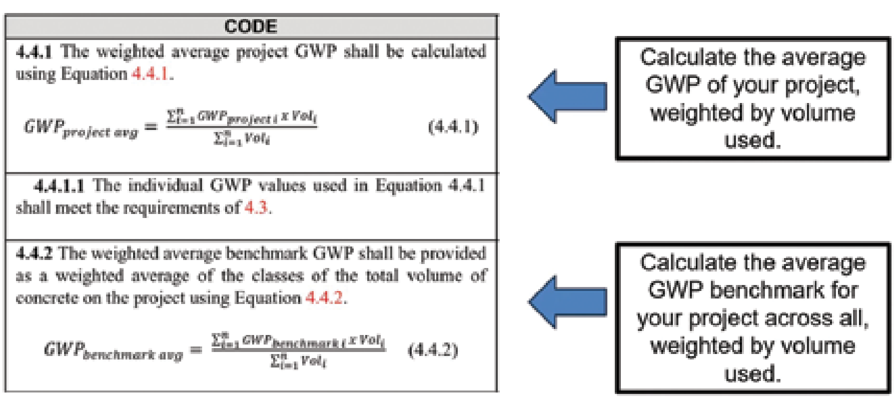


Fig. 6: The new Code specifies that project and benchmark GWP values are weighted averages

defined by its global warming potential (GWP), determined by using environmental product declarations (EPDs). Because many parameters will determine GWP for a project, successful policy must be dictated by performance standards. That is, policy should be based on finding a benchmark and defining the desired reduction relative to that benchmark. ACI Committee 323, Low-Carbon Concrete Code, recently published a new model building code to do just that. The new ACI CODE-323-24 will require designers to choose their compliance path based on the project type and size (refer to Fig. 5). While many project types are excluded from the current version of the document because of a lack of benchmark data, of the project types that are included in the code, the largest are required to attain a project GWP below a project benchmark (refer to Fig. 6). Designers of middle-sized projects are asked to document their project's GWP.

Adams concluded by advising innovators to develop guidance and specification documents to prove their technology works within the existing standards and methods.

The **2025 Concrete Innovation Forum** will provide attendees with the opportunity to connect with others in the industry and learn about current trends, emerging technologies, new products, and other innovations. The event will also provide opportunities for attendees to build strategic relationships and expand their networks. Save the date and join us this year in Denver, CO, USA, at Hotel Clio from August 12-14, 2025.

Program updates will be available on the ACI Foundation website: **www.acifoundation.org**.