Implementing Biochar for Low-Carbon Concrete

The ACI Foundation 2025 Concrete Innovation Forum brought together industry leaders, academics, and innovators to advance discussions on technology and sustainable practices in the concrete industry. Held at the Hotel Clio in Denver, CO, USA, the forum featured presentations centered on innovation and best practices for assessing and scaling new solutions to bring them to market. This article highlights a presentation from the forum, "Early Application of Biochar in Concrete through Stakeholder Education and Buy-in," developed by David Shook, Senior Associate Principal and Structural Engineer, Skidmore, Owings & Merrill (SOM), and Garrett Benisch, Chief Development Officer, Bioforcetech Corporation. This presentation focused on biochar's potential as a material for permanent carbon storage and the importance of gaining stakeholder alignment as a central factor for project success.

Urgency for Low-Carbon Materials

Shook began the presentation by highlighting the necessity of applying low-carbon materials in the industry today. While innovative technologies are being developed to help decarbonize the industry in the future, he focused on solutions applicable to the current market.

Shook described how the short carbon cycle holds 0.1% of Earth's upper-crust carbon—the rest is locked up in rocks and fossil fuels. When materials like fossil fuels are used, stored carbon is released into the atmosphere and into the short cycle. Biochar mitigates this effect by locking up large volumes of carbon in a stable form, which then can be used in a range of applications, including concrete.

He noted that biochar can be derived from a variety of sources. For example, biochar can be derived from agricultural products such as corn husks, rice husks, or wood chips; or it can be derived from wastewater biosolids—the solid residual from municipal wastewater treatment (commonly called sewage sludge). While biochar produced from agricultural products is showing promise as a supplementary cementitious material (SCM), biochar developed from wastewater biosolids is currently ready for use as fine aggregate in concrete. The latter product has been developed by Bioforcetech, a privately held company founded in 2013.

Production of Biochar from Wastewater Biosolids

Benisch divided Bioforcetech's biosolids to biochar production cycle into three different sections. "We divert materials, transform them, and then apply them. Each one has a different story, different impact, different way of looking at it," he said.

Diverting materials

Benisch noted that not all biomass (the broad term for organic materials ranging from wood chips and agricultural by-products to wastes) is created, valued, or behaves equally. Biomass can have differing characteristics such as moisture content, density, carbon content, and chemical content. As such, when discussing biochar, it is important to consider the biochar type and source. Benisch highlighted that wastewater biosolids comprise an "impact feedstock." By diverting these input sources from their current disposal or use streams, Bioforcetech alleviates emissive, costly, and/or contaminating practices. In short, if a material's management strategy is causing harm now, diverting that material to become biochar instead constitutes an 'impact feedstock.' He summarized two current industry options for biosolids management: landfilling it or applying it to land. The landfill option results in notable production of methane, a gas with a high global warming potential (GWP). While biosolids can feature nitrogen, phosphorous, and bioavailable carbon that can benefit soils, they also contain perfluoroalkyl and polyfluoroalkyl substances (PFAS), pharmaceuticals, microplastics, and heavy metals from upstream contamination. Applying biosolids to land therefore leads to soil and water contamination and is currently under regulatory and financial pressure in different parts of the United States.

Bioforcetech adds a third option. Their base-level system can convert 10 tons of wet biosolids into 1 ton of their OurCarbon® biochar, thereby minimizing emissions, avoiding contamination of soil and groundwater, and eliminating disposal fees.

Transforming biosolids with net-zero thermal inputs

Bioforcetech initiates the following proprietary transformation process for biosolids management:

- BioDryer: Bioforcetech dries biosolids using heat generated by bacteria flourishing within the biosolids feedstock and by heat from the oxidation of syngas (synthesis gas) generated during pyrolysis. Biosolids containing 80% moisture are fed into the BioDryer and dried to 20% moisture content;
- Sigma Pyrolysis Unit: Dried biosolids are transferred to the pyrolysis unit for carbonization, where they are transformed into OurCarbon. Heat is supplied from a heat exchanger at the syngas oxidation chamber and electric heating, with the latter used to adjust final temperatures to deliver exact carbonization parameters for OurCarbon output; and
- The running system is autogenous, producing carbon-negative material with the energy created by the material itself. Excess heat energy is shared to the BioDryers to eliminate any need for external heat from wet biosolids through to OurCarbon biochar.

Applying the transformed material

The company's environmental product declaration (EPD) shows the product is carbon negative. Benisch said that the biochar is not replacing cement or directly reducing the building construction footprint. Instead, this biochar application replaces aggregates using the mass of materials that do not currently have high emissions.

Benisch concluded with a study published by the University of California Davis, Davis, CA, USA, looking at the ability to store carbon in the new construction mass of the built environment. "If we replace materials that have equivalents that are carbon negative or have fixed carbon in new construction, we can sequester into the built environment half of all global emissions year over year, 16 gigatons, through that storage mass," he noted.

Case Study: The "Low-Carbon Campus"

OurCarbon biochar sourced from wastewater biosolids was successfully applied in concrete for a K-12 school project dubbed the "low-carbon campus" in Oakland, CA. Project collaborators included Bioforcetech, SOM, Vulcan Materials Company's Central Concrete, and Valorize Systems (formerly CarbonPilot). OurCarbon was infused into two different structural-grade concrete mixtures: a sitework mixture used for a stairway and entrance walkway to campus and a footing mixture used to anchor a retaining wall.

Project features included:

- The team used 100 lb (45 kg) of the biochar for the sidewalk. Shook noted they wanted to apply 300 lb (136 kg), but the biochar started darkening the color of the sidewalk. The team avoided disturbing the approved color;
- Third-party testing data was provided to verify that there were no organics. It was batch tested like fine aggregate;
- Biochar was used directly from the pyrolysis process, where most of it was around 0.5 to 3 mm (0.02 to 0.12 in.); and
- The material is around one-third carbon and two-thirds elemental ash. At the particle size used, there was no grinding of the material.

The team used a modest dosage of biochar on the project to minimize color change of the concrete. The biochar did not impact finishing or troweling, and it offset 16% of the GWP associated with the baseline concrete mixture. The percentage could have increased to 50% reduction in GWP at target dosage. The material ultimately acted as a suitable partial sand replacement.

Securing Stakeholder Alignment

Shook concluded by stressing the importance of stakeholder alignment in helping new technologies like biochar succeed. He noted that engineers should use their connections and platforms to create a network that facilitates bringing new technologies into projects. Stakeholders will include the architect, general contractor, owner or their representative concrete supplier, concrete mixture designer, concrete finishers, structural engineer, and, sometimes, city permitting staff, and each will bring their own set of questions that must be addressed to ensure alignment and trust and help the project succeed.

Shook described four stages for creating stakeholder alignment:

- First wave: Engineer reaches out to the concrete supplier and concrete mixture designer. These two entities are typically well aligned;
- Second wave: The general contractor is involved, and, if applicable, city permitting staff;
- Third wave: Conversations are brought to the owner. This is also when the architects typically get involved; and
- Fourth wave: All stakeholders are apprised. Attention should be given to finishers and placers.

Through 30 meetings with various stakeholders, his team was able to bring biochar into the low-carbon campus project. The supplier, Vulcan, was aware of biochar, but this was a new topic for most involved, which required a level of education. Shook emphasized how the engineer should be prepared to guide stakeholders and be intentional about how people are brought into conversations, so that the right answers can be given to those asking questions.

2026 Concrete Innovation Forum

Save the date for August 18-20, 2026, to attend the 2026 Concrete Innovation Forum at the Hyatt Regency in Columbus, OH, USA. At this event, industry leaders, researchers, and innovators will share more advancements and practical solutions for the future of concrete. This is an opportunity to connect, learn, and be inspired. In the meantime, the ACI Foundation will provide more articles in subsequent issues of *CI* to highlight presentations and insights from the 2025 Concrete Innovation Forum.

Selected for reader interest by the editors.