Innovation Shared at the ACI Foundation 2024 Technology Forum, Part 3

For over 25 years, the ACI Foundation has hosted Technology Forums to support ACI's expanding focus on advancing the concrete industry. These gatherings have been popular, 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 last of three articles that summarize the presentations made at the 2024 Technology Forum.

These Forum presentations can be downloaded at **https://www.acifoundation.org/portals/12/Files/CIC/2024-Technology-Forum-Presentations.zip**.

Reducing Embodied Carbon without Using Carbon Credits

Presented by Forrest Etter, Director, Design and Construction Innovation, Prologis, Inc.

The world's largest industrial real estate developer, Prologis, manages distribution centers on four continents. With assets totaling 1.2 billion ft^2 (111 million m^2), the company is continually starting new developments. The company has committed to being net zero by 2040, which requires a 90% reduction of embodied carbon in new construction. Because concrete makes up roughly half of the carbon footprint for warehouse construction (refer to Fig. 1), concrete innovations are a major focus of the company's decarbonization efforts. Etter described Project Nexus, a recent Prologis project (refer to Fig. 2). The company partnered with Central Concrete Supply, Whiting Turner, Bradley Concrete, and HSA Structural Engineers to create a state-of-the-art, 260,000 ft^2 (24,150 m^2) industrial building with a 40 ft (12 m) clear height. The building, in San Leandro, CA, USA, was constructed with a global warming potential (GWP) of less than 60% of a benchmark structure, a traditional Prologis warehouse. This was achieved using an innovative structural design and three core strategies: reuse, design optimization, and low-carbon mixture design.

Big Data Trends: Outcomes of Implementing an Automatic Feedback System to Manage Slump during Delivery of Ready-Mix Concrete

Presented by Nathan Tregger, Director of Data Analytics, Verifi LLC

Over 20 million deliveries of ready mixed concrete have been monitored using onboard sensors to measure concrete properties such as slump, temperature, and age, as well as truck properties such as GPS location, mixer drum speed, and revolutions. Over a third of these deliveries have also been managed through automatic additions of either water,

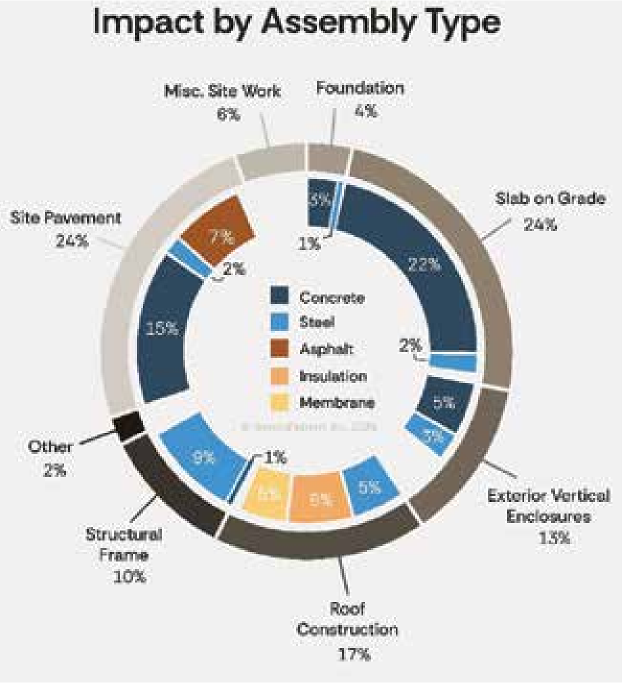


Fig. 1: A study commissioned by Prologis showed that concrete makes up about 45% of the embodied carbon footprint for a warehouse project *(courtesy of BranchPattern, Inc.)*

Fig. 2: Project Nexus achieved significant reductions in embodied carbon by reusing materials and optimizing the design of the slab and concrete mixture

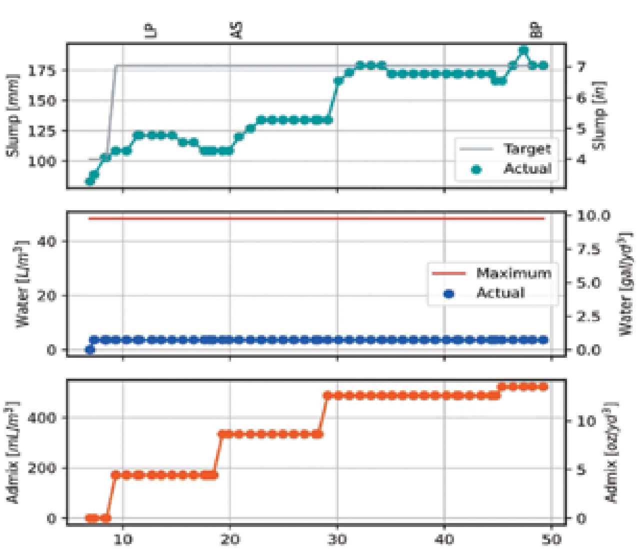


Fig. 3: The VERIFI® system has been used in the delivery of over 200 million yd³ (5.5 million m³) of concrete, allowing the collection of over a billion data points. The system can automatically add water or admixture to meet a target slump

chemical admixtures, or both (refer to Fig. 3). Tregger reflected on outcomes of slump management, including reduced variability of delivered slump (that is, managed versus unmanaged), productivity opportunities (refer to Fig. 4), and a major potential for carbon dioxide (CO_2) reduction (including an example in which a ready mixed concrete producer achieved a reduction of over 1 million lb [450,000 kg] of CO_2 in a year). The ability to measure and manage every delivery generates a large quantity of data, enabling informed changes to operations and mixture designs while simultaneously reducing risk.

A Material Science-Based and Data-Driven Approach Towards Sustainable and Durable Infrastructure

Presented by Kai Gong, Assistant Professor, Rice University

Kai Gong has established the Sustainable Infrastructure Materials (SIM) group at Rice University, Houston, TX, USA.

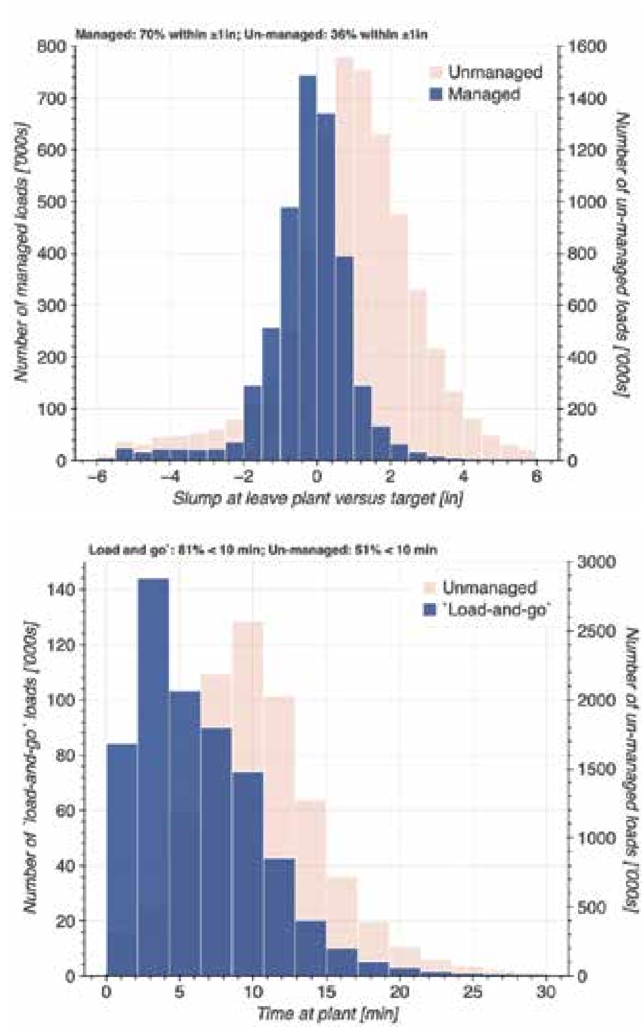


Fig. 4: Automatic management of slump reduces the standard deviation, and enables major productivity boosts by minimizing the time a truck spends at the plant (a truck can load and go) as well as time on site

SIM focuses on critical and challenging materials science problems related to industrial decarbonization, waste encapsulation, waste-to-resources, digital fabrication, and sustainable and durable infrastructure materials. To achieve its goals, the group employs a dual strategy: a top-down approach and a bottom-up approach (refer to Fig. 5). One example was discussed for each approach. The top-down approach involves using machine learning (ML) models and inverse optimization techniques to design concrete mixtures that minimize CO_2 emissions while maintaining performance. The bottom-up approach has been focused on uncovering the atomic structural fingerprint of highly complex and amorphous aluminosilicates in low-CO_2 solid wastes (refer to Fig. 6). This approach has the potential to be developed into a rapid pre-screening method for assessing the suitability of waste materials for concrete production. The limitations of these methods were discussed alongside future research directions to refine these strategies and broaden their applications. Through this integrated approach, the SIM group aims to develop innovative solutions to critical challenges in sustainable infrastructure and materials science.

Fig. 5: Schematic illustration of the research focus and approaches of the SIM group at Rice University. SIM is particularly aimed at addressing critical challenges in sustainable infrastructure and materials

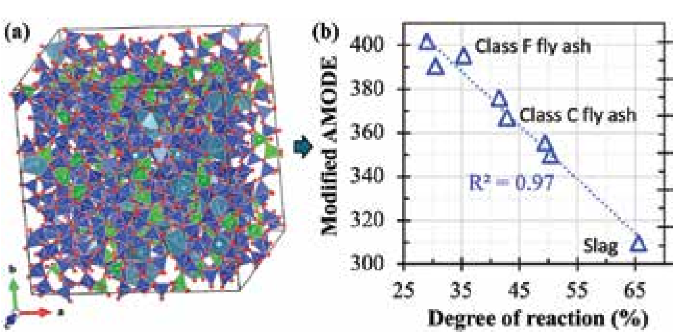


Fig. 6: SIM is applying a bottom-up approach to investigate industrial by-products: (a) a typical atomic structure generated for a calcium aluminosilicate glass using atomistic simulation; and (b) physics-based compositional parameters such as a modified average metal-oxygen dissociation energy (AMODE) can effectively capture the relative reactivity of amorphous calcium aluminosilicate glasses, with compositions encompassing those of fly ash and slag (the original experimental degree of reaction data was sourced from: Kucharczyk, S.; Zajac, M.; Stabler, C.; Thomsen, R.M.; Haha, M.B.; Skibsted, J.; and Deja, J., "Structure and Reactivity of Synthetic CaO-Al_2O_3-SiO_2 Glasses," *Cement and Concrete Research*, V. 120, June 2019, pp. 77-91)

Reverse Engineering: The Power of Beginning with the End in Mind

Presented by Cary Kopczynski, CEO & Senior Principal, Cary Kopczynski & Company, Inc.

Reverse engineering involves optimizing a project's construction plan before beginning detailed structural design. By first identifying efficient construction strategies, unnecessary design complexity can be eliminated, innovation stimulated, and constructability improved. The improved constructability of design leads to improved productivity of construction, which is the mission of PRO: An ACI Center of Excellence for Advancing Productivity (refer to Fig. 7). Kopczynski elaborated on these concepts using successful project case histories (refer to Fig. 8), and he explained how

BAKER CONCRETE (PLATINUM MEMBER)
CECO CONCRETE (SILVER MEMBER)
CONCO (SILVER MEMBER)
SOMERO (SILVER MEMBER)
CEMEX (BRONZE MEMBER)
PS=Ø (BRONZE MEMBER)

Fig. 7: PRO and its members aim to advance new technologies and processes that improve productivity beyond historic levels

Fig. 8: The Snoqualmie Casino Hotel structure is a reinforced concrete frame with post-tensioned slabs and two shear wall cores. The layout was designed to accommodate a column-hung forming system for slab construction, thus eliminating the need for shoring and reshoring and facilitating early access by MEP and finish workers

PRO is engaging with the concrete industry to stimulate innovation and efficiency.

Revolutionizing Concrete Production with AI: Bridging the Gap Between Innovation and Application

Presented by Andrew Fahim, Research & Development Engineer, Giatec Scientific Inc.

Giatec builds and trains models based on artificial neural networks, using a data set representing 75 million m^3 (2.6 million ft^3) of concrete produced by 1500 plants (refer to Fig. 9). The data set includes 300,000 unique mixtures, 2000 raw materials, and over 100 test methods, and it has been used to create models with predictive capabilities for in-transit, fresh, and hardened properties. The data of immediate value include proportions, material types and sources, performance, specifications, and delivery information.

Using this expertise, Giatec is building what they call SmartMix—a platform that allows them to collect data from ready mixed concrete producers and identify opportunities for optimization. Data are collected from batching systems, in-transit systems, and jobsite tests, and the platform's algorithms generate options within seconds (refer to Fig. 10). If a producer accepts the optimizations, the revision is automatically pushed to the batching system. This is true mixture management rather than mixture maintenance.

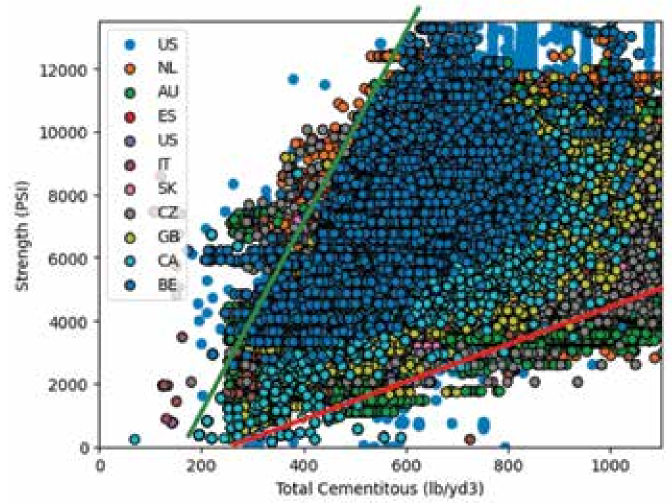


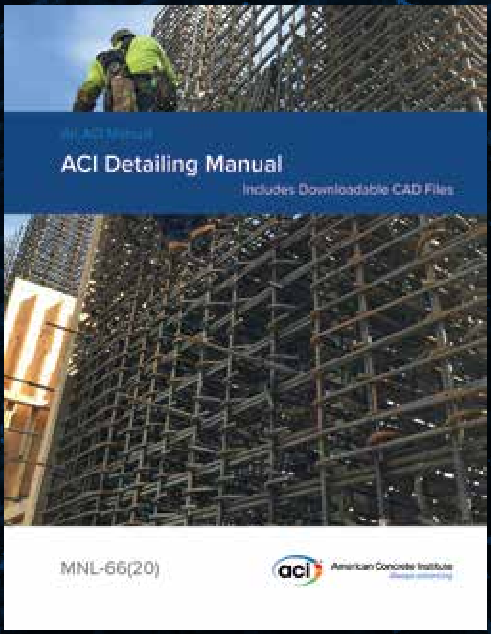
Fig. 9: Giatec has collected data from concrete producers throughout the world

The ACI Detailing Manual

Includes FREE Downloadable CAD Files

The 2020 edition of the *ACI Detailing Manual* includes many new updates and revisions, plus the addition of valuable downloadable CAD files.

Visit **concrete.org/store** for more information.



aci American Concrete Institute *Always advancing*

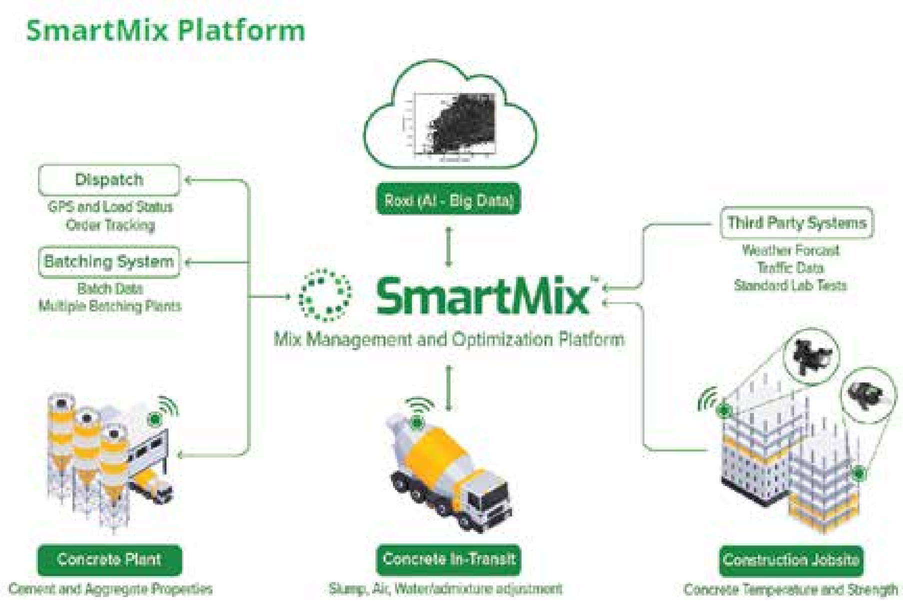


Fig. 10: A schematic of the SmartMix platform's interactions with data generated at the plant, in transit, and at the jobsite

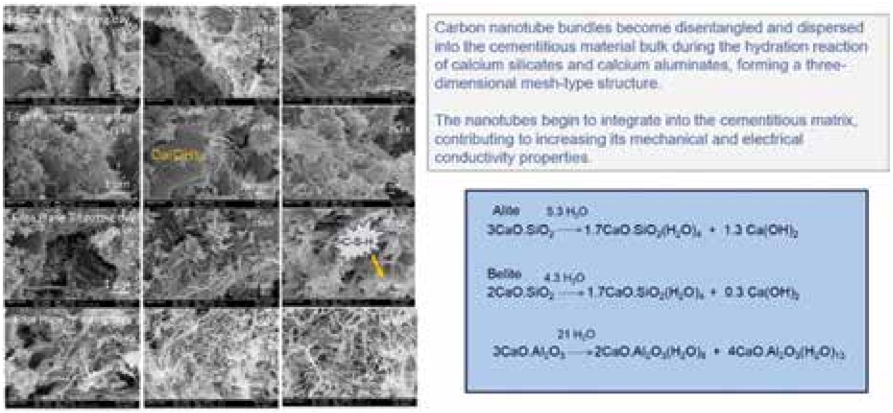


Fig. 11: CHASM's CNT hybrids become disentangled and dispersed during the hydration reaction

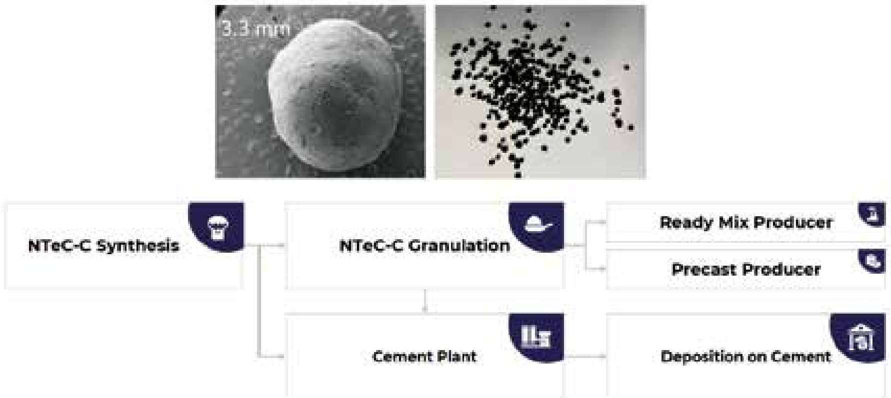


Fig. 12: After synthesis, the CNT powder can be integrated directly into cement, or it can be granulated. The granules may be integrated into cement or into concrete

NTeC-C, Carbon Nanotube Reinforcing Additives for Concrete

Presented by Ricardo Prada Silvy, Chief Technology Officer, Chasm Advanced Materials

CHASM's scalable and cost effective NTeC®-C carbon nanotubes (CNT) technology leverages low-cost hydrocarbon feedstock to co-produce clean hydrogen and high-value carbon products. Despite the proven potential of CNT technology to enhance concrete strength, adoption has been hindered by high costs associated with traditional production methods as well as ineffective dispersion of CNTs in concrete mixtures. CHASM's NTeC® solution overcomes these barriers with a CAPEX-efficient rotary kiln process that synthesizes CNT hybrids on cement-compatible particles, ensuring seamless dispersion during hydration (refer to Fig. 11). The synthesis methods result in various products, including self-dispensing CNT granules (refer to Fig. 12) and cement powder with pre-deposited CNTs. NTeC CNTs significantly enhance concrete performance by boosting flexural strength, improving early and 28-day strengths, and reducing cracking and permeability.

2025 Concrete Innovation Forum

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**.