MITIGATING THE CARBON FOOTPRINT OF ***CONCRETE***

November 20, 2021 11:00am -12:30pm

The carbon footprint from the billions of tons of concrete placed each year is substantial, resulting in nearly 8% of total global emissions. This session will provide attendees with tools to reduce the carbon footprint of concrete through use of high-volume cement substitutes, concrete mix optimization, and carbon sequestering technologies.

LEARNING OBJECTIVES

- Understand the carbon impacts of concrete and Portland Cement, and methods to mitigate the impacts.
- Identify Portland Cement substitutes, both natural pozzolans and industrial byproducts, and the effects they have on concrete structures during placement and use.
- Understand technologies for carbon sequestration in cement, manufactured aggregates, and concrete.
- Recall the benefits, costs and challenges of technologies and materials to reduce the carbon footprint of concrete structures.

ASLA 2021 Conference on Landscape Architecture NOVEMBER 19-22 | Nashville, TN

SPEAKERS

MEG CALKINS FASLA, SITES AP, NC STATE UNIVERSITY

Meg Calkins, FASLA, SITES AP, is the department head and a professor of Landscape Architecture and Environmental Planning at North Carolina State University. She is the author of the book Materials for Sustainable Sites and editor of the Sustainable Sites Handbook. Calkins has taken an active leadership role in development and implementation of the Sustainable Sites Initiative (SITES) since 2003. She is a frequent contributing editor to Landscape Architecture magazine writing several articles on site construction materials and exemplary designed works.

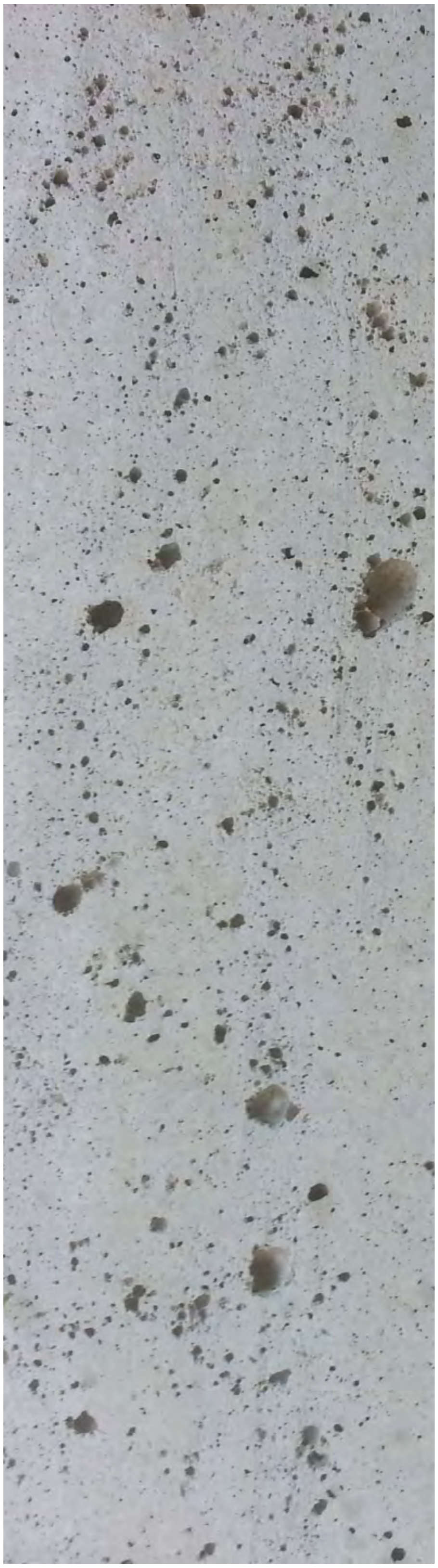
KEVIN BURKE FASLA, ATLANTA BELTLINE

Mr. Burke is the Director of Design for Atlanta BeltLine Inc. and has thirty-nine years of experience on a plethora of institutional, roadway, college/university, residential, multi-use trail, and park projects. He coordinates design and construction efforts for all public open spaces and serves as the chair of the ABI Design Review Committee. He implemented the requirement that all ABI projects initiated since 2018 will be SITES certified and was the organizer of ABI's Organic Land Care Symposium which informed the public about more sustainable ways of maintaining our public spaces. Mr. Burke has a Bachelor of Landscape Architecture degree from Utah State University and, in 2019, became a Fellow of the American Society of Landscape Architects.

JENNY MITCHELL LEED AP BD+C, LINKEDIN

Jenny joins us from LinkedIn's Global Workplace team headquartered in Mountain View, California where she manages the capital portfolio of the Mountain View/Sunnyvale headquarters campus expansion. She has more than twenty years-experience in the construction industry leading projects throughout the Bay Area in the roles of concrete manufacturer, general contractor, client representative, and owner. With a passion for sustainability, Jenny is leading the concrete carbon reduction mission for LinkedIn's new Mountain View Headquarters Campus. Jenny earned a Master of Arts degree in Environmental Studies with a Concentration in Sustainable Development and Policy from the University of Illinois, and a Bachelor of Arts degree in Environmental Studies accompanied by a Minor in Business Administration from San Jose State University.

PRESENTATION OUTLINE



I. **Session Introduction**
   A. Introduction of speakers
   B. Learning Objectives

II. **Understanding the Carbon Footprint of Portland Cement Concrete (PCC)**
   A. Carbon impacts of PCC compared with alternative materials
   B. Carbon impacts of Portland Cement, aggregates and reinforcing
   C. Longevity of concrete site structures

III. **Technologies and Strategies to reduce the carbon footprint of Portland Cement concrete**
   A. Reducing the carbon footprint of Portland Cement Manufacture
   B. High volume substitutes for Portland cement
      - Fly Ash
      - Ground granulated blast furnace slag
      - Calcined clay
      - Metakaolin
   C. Carbon Sequestration in Cement, Aggregates and concrete
      - Carbon sequestration in cement
      - Carbon sequestration in ready mix concrete
      - Carbon Mineralization and Aggregates
      - Carbon sequestration in precast concrete products
   D. Reducing performance specs
      - Reduced strength performance (4000 to 3000)
      - 56 day break time instead of 28 day
   E. Reducing resources
      - Don't overbuild (eg. 6" slab instead of 8")
      - Recycled aggregates – Glass, plastics, coal by-products, foundry sand
      - Reducing waste
      - Using local materials
      - Recycled concrete as aggregate base material

IV. **Low carbon concrete technologies used at the LinkedIn Campus and lessons learned through their use**
   A. LinkedIn Campus 2030/2050 Sustainability goals
   B. LinkedIn Headquarters Phase 1, Mountain View CA: The first concrete mission
      - Mix Optimization - smart design and expanding the library
      - SCM's - high replacement
      - Carbon Mineralization - piloted technology
   C. Influence: The next concrete mission
      - Widespread adoption throughout Silicon Valley
      - Rapid engagement and action throughout California
      - Sustainable strategies for concrete products
      - Concrete Industry Start-ups and VC funding
   D. The Partner Approach - How and why the approach was succesful
   E. The Owner's Priorities - How to help your client

PRESENTATION OUTLINE

V. **Current concrete technologies used at the Atlanta Belt Line and lessons learned through their use**

A. Brief Project Overview
- Atlanta BeltLine Corridor
- Trail Sample
- GA DOT v. Local Funding
- Decision to Use Concrete

B. Sustainability Goals and guiding principles
- To create and encourage a community dedicated to environmental sustainability through innovative leadership
- Deliver projects to the City which advance the state of environmentally sensitive and sustainable City owned infrastructure
- Use BeltLine projects as test bed for new technologies and approaches where appropriate
- Develop infrastructure that can be adequately maintained post construction to the benefit of ABI, COA, and the community.
- Create a walkable environment via paths and streetscapes. Create spaces where people want to go and environments that enhance the experience and get people out of cars.
- Materials for the BeltLine corridor should be selected through a lifecycle analysis and considering the ecological footprint of the material from cradle-to-grave

C. Construction progress to date
- Materials
- Constraints
  1. Funding Sources
     a. GDOT/Federal
     b. Local Funding
        i. TAD (Tax Allocation District)
        ii. Philanthropy
        iii. SSD (Special Services District

D. Concrete carbon mitigation strategies used
- Long-term durability maximization
- Focus on life cycle costs
- Substitutes for Portland cement
- Revised break test time frame to 56 days, 70% goal at 28 days
- Communication and collaboration with construction partners
- Working with Argos Concrete and Design team to create performance specifications to facilitate options to reduce carbon
- Are there increased costs for these changes?

VI. **Conclusions**

Recapping considerations for reducing carbon footprint of concrete
Working with contractors, engineers and specifiers to maximize success
Cost tradeoffs

GENERAL RESOURCES

Atlanta Beltline path using high volume cement substitutes in the concrete mix

LinkedIn Campus construction using multiple low carbon concrete strategies

Athena Sustainable Materials Institute
http://www.athenasmi.org/

The Athena Sustainable Materials Institute is a non-profit research collaborative bringing life cycle assessment to the construction sector. Life cycle assessment (LCA) is the science behind environmental footprinting. The Athena Institute works with sustainability leaders in product manufacturing, building design, construction, and green labelling programs to enable smaller footprints in the production and consumption of construction materials (Athena Sustainable Materials Institute).

Athena Pavement LCA
http://www.athenasmi.org/our-software-data/pavement-lca/

This software tool provides environmental LCA results for Canadian and select US regional materials manufacturing, roadway construction and maintenance life cycle stages. It allows custom roadway design, or users can draw from a library of over 150 existing roadway designs. The software includes a large equipment and materials database and the flexibility to specify unique pavement systems – sub-base and base granular materials as well as hot and warm mix asphalt and a host of user-specified concrete mix designs. Users can also input use-phase operating energy and apply built-in pavement vehicle interaction algorithms, if desired, to be included in the final LCA results. The software allows for quick and easy comparison of multiple design options over a range of expected roadway lifespans (Athena Sustainable Materials Institute).

Architecture 2030
https://architecture2030.org/

Our mission is to rapidly transform the built environment from the major contributor of greenhouse gas emissions to a central solution to the climate crisis. Architecture 2030 provides the leadership and designs the high-impact actions needed to achieve a carbon-neutral built environment by 2040 (Architecture 2030).

Carbon Smart Materials Palette
https://materialspalette.org/

The Carbon Smart Materials Palette contains an attribute-based approach to embodied carbon reductions in the built environment. It identifies key attributes that contribute to a material's embodied carbon impact, and offers guidelines and options for emissions reductions. The Carbon Smart Materials Palette is designed to support and complement Life Cycle Assessments (LCAs) and Environmental Product Declarations (EPDs), while providing highly impactful guidelines for low/no carbon material selections and specifications (Carbon Smart Materials Palette).

Environmental Product Declarations

An Environmental Product Declaration (EPD) is an independently verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of products (International EPD System).

- https://www.environdec.com/EPD-Search/
- https://spot.ul.com/
- US: https://spot.ulprospector.com/en/na/BuiltEnvironment
- Germany: https://ibu-epd.com/en/published-epds/
- Ireland: https: //www.igbc.ie/epd-search/
- UK: http://www.greenbooklive.com/search/scheme.jsp?id=260

GENERAL RESOURCES

Accelerated carbonation technology (ACT) uses carbon gas to treat thermal wastes. The result is the production of stable carbonates that are blended with binders and fillers then pelletized to form artificial limestone, such as this product from Carbon 8 (Image courtesy of Carbon 8).

LOW CARBON CONCRETE STRATEGIES AND PRODUCTS

Low Carbon Cement Materials

Fly Ash is a by-product of coal combustion and composed primarily of silicon dioxide (SiO2) and calcium oxide (CaO). It will become limited in alternative energy sources are used and coal combustion is reduced.Ground granulated blast furnace slag (GGBFS), more commonly referred to as slag or slag cement, is a by-product of steel production. Silica Fume is a by-product from silicon alloy production in electric arc furnaces. Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Volcanic Ash is formed during volcanic eruptions it is readily available in California.

Energetically Modified Cement

Energetically modified cement (EMC) allows for substitution of the above cement alternatives in much higher percentages. EMC activation is a process that modifies the surface of hydraulic materials such as fly ash, natural pozzolans (such as silica sands and metakaolin) and blast furnace slag. This process increases the surface area of the particles, rendering micro cracks and dislocations of crystal structures at the nano scale. This results in greater reactivity with no significant increase in powder fineness, which allows for much higher substitutions for Ordinary Portland Cement (Calkins 2017).

EMC Cement https://lowcarboncement.com/

The Swedish company claims the following percentages for cement substitutions with the EMC process: Natural (volcanic) pozzolans ~70%; Fly ash ~80%; Slag ~95% binders and fillers then pelletized to form artificial limestone (Calkins 2017).

Solidia technologies produces carbon cement and cures concrete with CO2 instead of water resulting in up to a seventy percent reduction in the carbon footprint of concrete products (Image courtesy of Solidia Technologies)

LOW CARBON CONCRETE STRATEGIES AND PRODUCTS

CarbonCure Technologies https://www.carboncure.com/

CarbonCure injects a precise dosage of carbon dioxide (CO_2) into concrete, where the CO_2 becomes chemically converted into a mineral. Once injected into the wet concrete mix, the CO_2 reacts with calcium ions from cement to form a nano-sized mineral, Calcium Carbonate, which becomes embedded in the concrete (CarbonCure Technologies). The CarbonCure process is available at Ready Mix producers worldwide. In the US, nearly 250 producers offer this primarily in the southeast, Midwest and west coast.

Solidia Technologies https://www.solidiatech.com/solutions.html

Solidia Technoligies has developed a non-hydraulic cement that is low lime, containing primarily calcium silicates. CO2 emissions from production of Solidia cement are reduced by about 30 percent, owing to its low lime content and an 18 percent reduction in firing temperature. Solidia cement cures with a carbonation process, not through the typical hydration activation process of OPC. Waste CO2 used for curing is injected into the concrete mix in amounts equal to about 5 percent of the mix weight. Combined, Solidia cement and concrete can reduce the carbon factor of concrete up to 70 percent or about 550 kg per metric ton (Calkins 2017).

GENERAL RESOURCES \\ SOURCES

Reclaimed materials to reprocess into concrete aggregate.

CARBON MINERALIZATION PRODUCTS

Carbon 8 Systems https://c8s.co.uk/
Carbon 8 is a British company that uses accelerated carbonation technology (ACT) to produce carbon-negative lightweight aggregates. ACT uses carbon gas to treat thermal wastes resulting in the production of stable carbonates that are blended with binders and fillers then pelletized to form artificial limestone (Calkins 2017).

Blue Planet https://www.blueplanet-ltd.com/
Blue Planet, a California Company, has developed another carbon capture and mineralization technology that produces aggregates and sack concrete. Its biomimetic technology uses osmotic pressure between fresh and salt water to create a proprietary alkaline solution, which is then combined with CO2 from flue gas to form carbonates. This process is inspired by naturally occurring marine biomineralization. Blue Planet offers CO2 capture as an emissions control service and the company is currently interviewing candidates for project demonstration. Its website states that potential sites include fossil-fuel-powered electricity generating facilities, refineries, and cement plants (Calkins 2017).

SOURCES

Global Cement and Concrete Association. GCCA Climate Ambition Statement: Toward Carbon Neutral Concrete. London: September 2020.

Meg Calkins. "Concrete Minus Carbon: New technologies can reduce the environmental footprint of the most used construction material". Landscape Architecture Magazine. Washington, DC: ASLA, July 2017.

Gajanan M Sabnis, Ed. Green Building with Concrete: Sustainable Design and Construction, Second Edition. Boca Raton: Taylor and Francis Group, 2016.