BUILDING INNOVATION
Conference

Innovations and Operations:

Developments in Sustainable Precast Concrete

Jim Schneider, LEED AP

Executive Director, PCI Mountain States

PCI
Precast/Prestressed Concrete Institute

HOW PRECAST BUILDS®

BUILDING INNOVATION Conference

Speaker:
Jim Schneider, LEED AP

- Executive Director of the PCI Mountain States chapter, which covers Colorado, Idaho, Montana, Utah, and Wyoming.
- Has worked with architects, engineers and building professionals for nearly two decades.
- Previously the editor of several business publications, including *Eco-Structure*, Ascent, *Plumbing Engineer*, *PHC News*, and *Metalmag*.
- A regular contributor to several national and regional industry publications, including *Retrofit*, *Smart Buildings Technology*, *Retrofit Home*, *Ascent* and *Colorado Design & Construction*.
- Father of two, author, passionate about efficient, sustainable design, and thinks concrete is cool, even if my kids don't always believe it.

BUILDING INNOVATION
Conference

BUILDING INNOVATION
Conference

BUILDING INNOVATION
Conference

Course Description

Concrete is a durable, resilient material that can provide many benefits to efficient, sustainable structures in the long term. While concrete does have an up-front CO_2 impact, the industry is working to reduce GHG emissions and increase the efficiency of its products.

This presentation will discuss technical innovations to reduce the carbon footprint of concrete and examine current process improvements that are pushing the industry forward to a more sustainable future.

Learning Objectives

1. **Learn** — Attendees will learn about attributes, benefits and considerations of using concrete in the holistic design of sustainable structures.

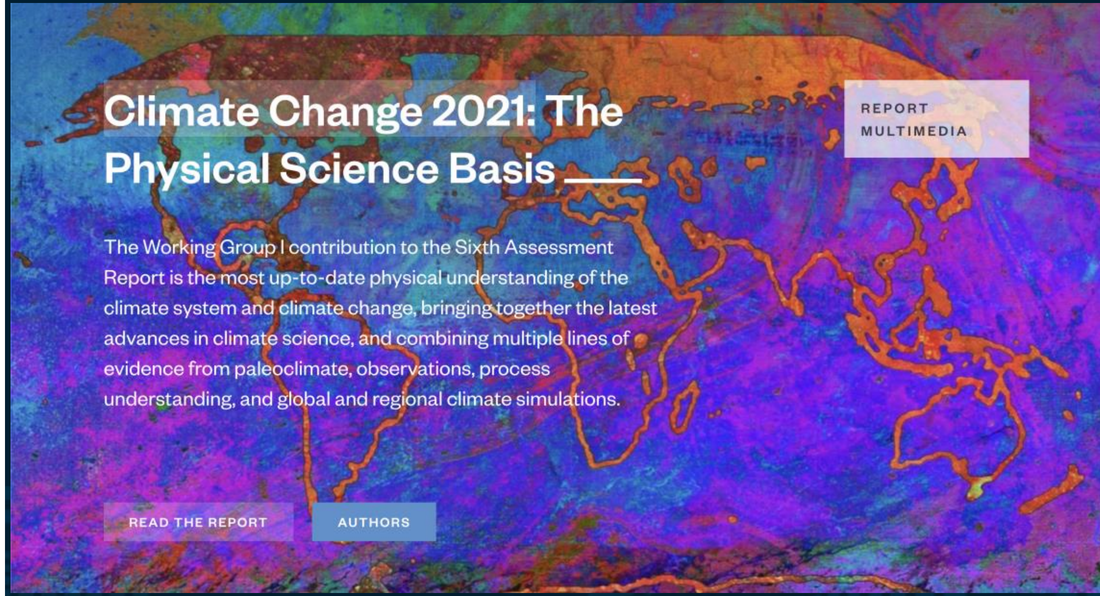
2. **Understand** — Participants will understand established and developing technologies aimed at reducing the environmental impact of concrete.

3. **Discover** — Attendees will discover process improvements, production efficiencies and other producer efforts that are creating GHG reductions today..

4. **Demonstrate** — Demonstrate ways that concrete producers are lowering the environmental impact of their products, and how projects are achieving sustainability goals with concrete.

Build for Tomorrow

- Climate change is here. The world is changing
- The recent IPCC report indicates we need to accelerate our efforts to mitigate the impacts of climate change, while also preparing for inevitable change.
- The changing environment means buildings will experience more stress in the coming decades.
- More important than ever to build with both sustainability and resilience in mind.



What is Sustainable Design?

“Sustainable design seeks to reduce negative impacts on the environment, and the health and comfort of building occupants, thereby improving building performance. The basic objectives of sustainability are to reduce consumption of non-renewable resources, minimize waste, and create healthy, productive environments.”

From the U.S General Services Administration definition of sustainable design

Building Impact: By the Numbers

- According to the United Nations Environment Program, buildings and their construction worldwide account for 36 percent of global energy use and 39 percent of energy-related carbon dioxide emissions each year.

- U.S. Energy Administration data from 2018 shows that residential and commercial buildings account for 40 percent of energy usage in the United States.

Building Impact: By the Numbers

- According to USGBC, buildings account for 13.6 percent of potable water use in the U.S. That is the third-largest category, behind thermoelectric power and irrigation.

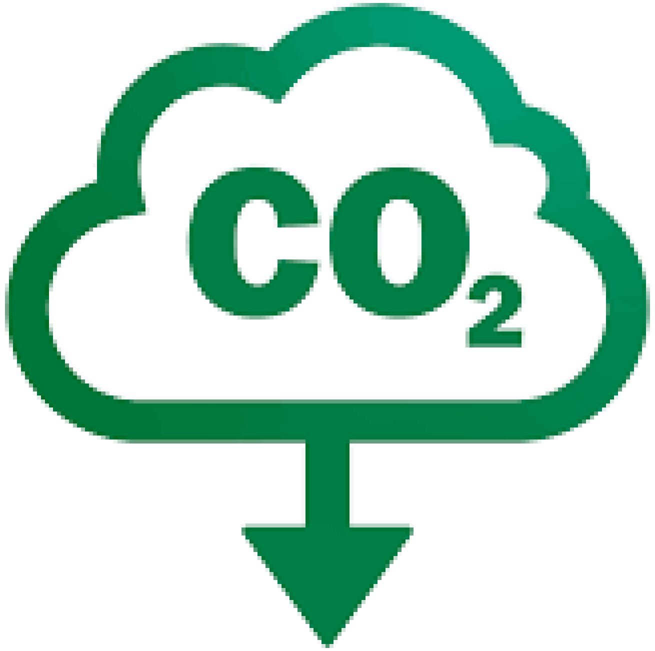
- The building industry consumes 40% of the raw materials flow of the global economy every year.

- EPA estimates that 569 million tons of construction and demolition waste were generated in the United States in 2017. That is more than twice the amount of generated municipal solid waste.

Working Toward Carbon Reduction

- The concrete industry recognizes the need for immediate reductions in greenhouse gas emissions.

- Numerous new technologies and techniques are emerging to minimize the initial impact of manufacturing concrete.



What is Embodied Carbon?

- Definitions of embodied carbon differ. Some view the embodied carbon of a building as including the entire life cycle of the materials, even the operational phase of the building. A full life-cycle view of embodied carbon would account for impacts of landfilling or recycling materials as well.
- Others focus on initial embodied carbon, which are the impacts associated with extracting, manufacturing and transporting materials to the jobsite.
- “Carbon” is used to indicate all greenhouse gas emissions, not just carbon dioxide.

Source: BuildingGreen

Material Matters

All building materials contribute to the carbon footprint of a building in different ways.

- **Concrete:** It contributes 6 to 11 percent of global carbon dioxide emissions. Most of it comes from the production portland cement, which comprises about 10 percent of the concrete mix. Producing aggregate also requires some energy, mostly from transportation.
- **Steel:** Manufacturing virgin steel from iron ore is very energy intensive. The global steel sector has a large carbon footprint, contributing upwards of 10 percent of global carbon dioxide emissions.
- **Wood:** Its manufacture produces fewer emissions than steel and concrete, but there is much debate about the overall impact. More research is needed on the carbon emissions of the logging, processing, transport and maintenance of wood products.

Source: Architect magazine, January 2020

Looking at the Big Picture, Products and Operation

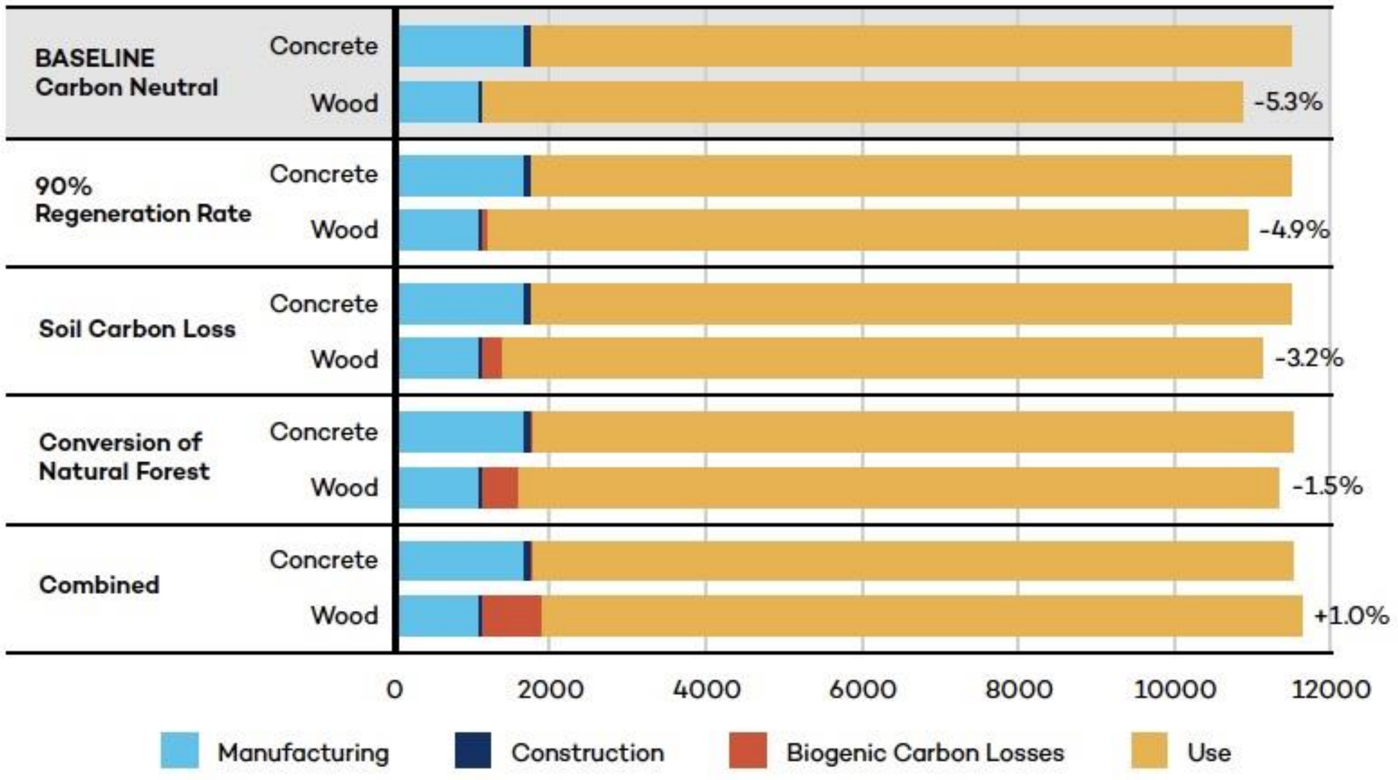


Figure ES2. Building embodied and use emissions (tCO_2e)

Source: International Institute for Sustainable Development report, "Emission Omisissions"

World of Concrete

- Concrete is the most abundant man-made material in the world.
- Estimates range between 4 and 10 billion tons of concrete produced globally each year.
- Concrete provides durability, resilience, quality and many attributes.
- We need it.
- We need to make it better and less impactful to the environment.

HOW PRECAST **BUILDS**®

Innovations

PCI
Precast/Prestressed
Concrete Institute

Three Main Goals

- Reduce the use of traditional Portland cement.
- Offset or mitigate the carbon emitted in the production of concrete.
- Increase strength while reducing material use

Cement Improvements

Portland Limestone Cement (PLC)

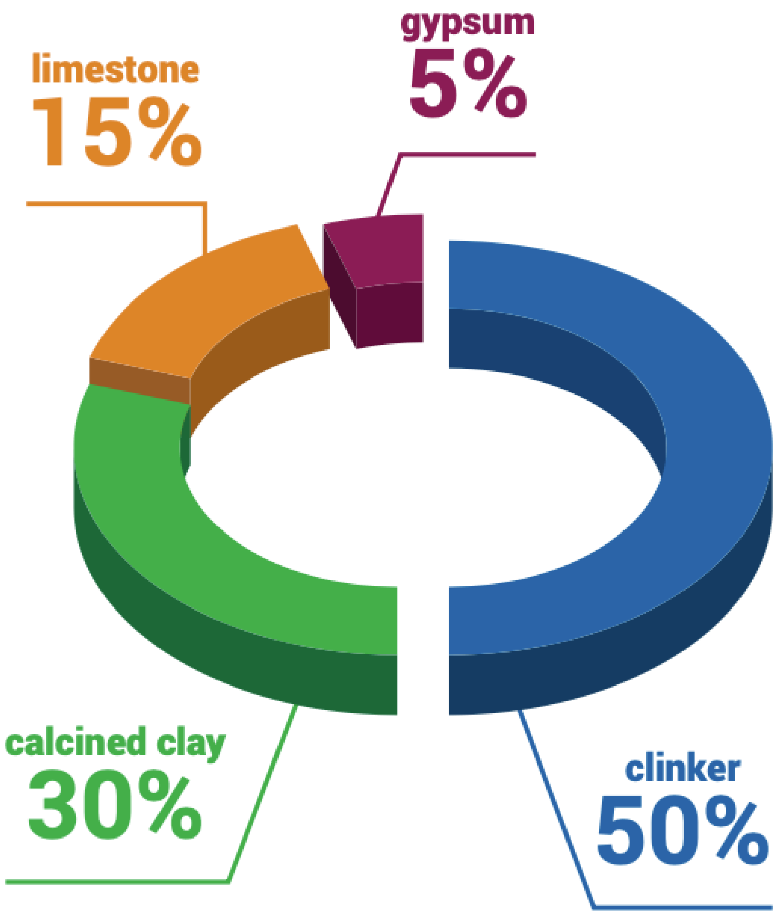
Limestone Calcinated Clay Cement (LC3)

Utilizing more energy efficient heating technologies

Portland Limestone Cement (PLC)

- Portland-limestone cement (PLC) is a blended cement with a higher limestone content
- It works the same, measures the same, and performs the same as regular Portland cement.
- Often needs only minimal adjustments in mix designs.
- Reduces carbon impact by about 10 percent.

Limestone Calcinated Clay Cement (LC3)



- Based on a blend of limestone and calcined clay
- Made using limestone and low-grade clays which are available in abundant quantities
- Cost effective and does not require capital intensive modifications to existing cement plants
- Can reduce CO2 emissions by up to 40%

Supplementary Cementitious Materials

Supplementary cementitious materials (SCMs) can be used to reduce cement content. Some common SCMs include:

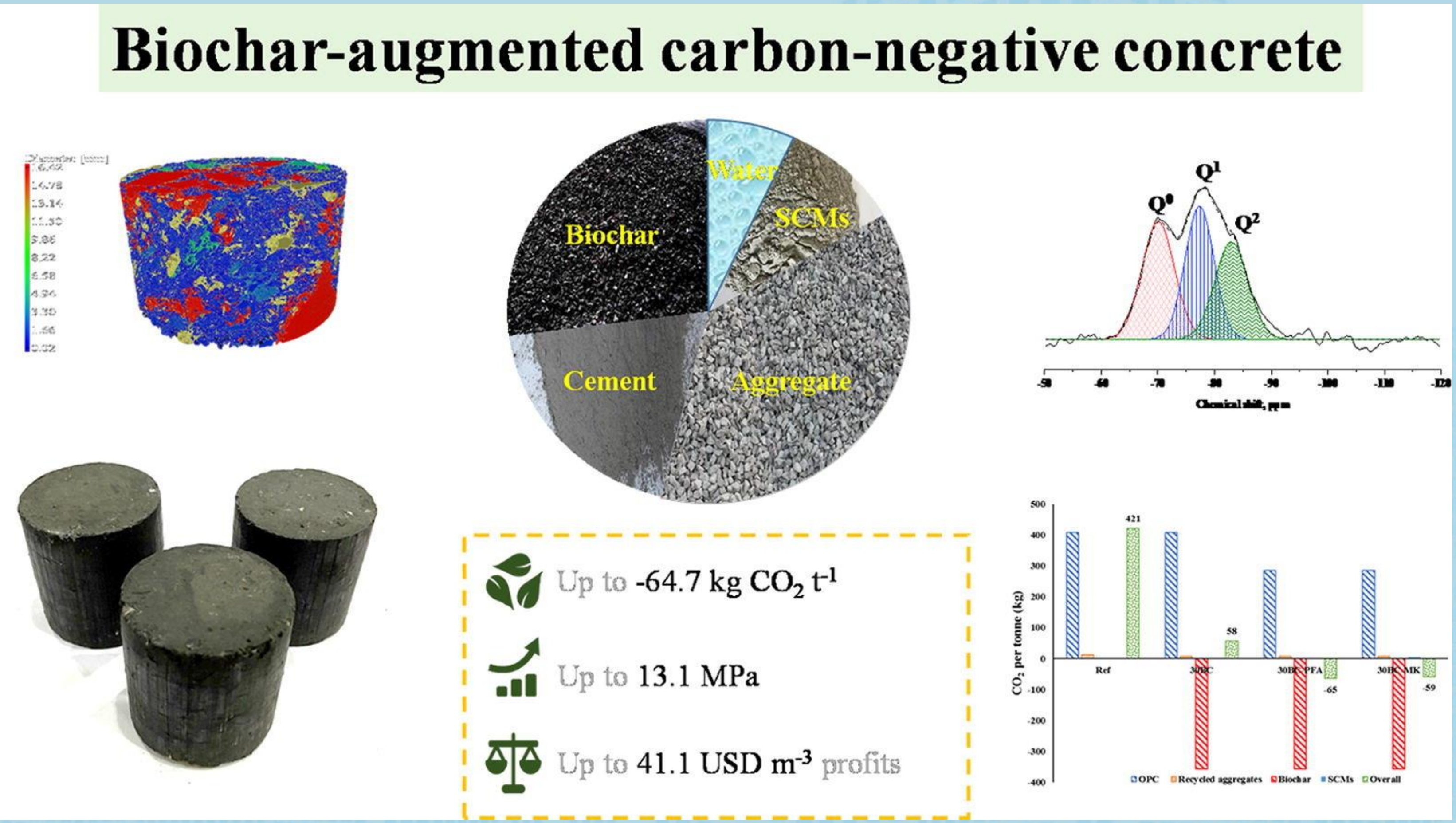
- **Fly ash.** A coal byproduct. Commercially available fly ash is a finely divided residue that results from the combustion of pulverized coal and is carried from the combustion chamber of the furnace by exhaust gases.
- **Slag Cement.** A glassy, granular material formed when molten, iron blast-furnace slag is rapidly chilled - typically by water sprays or immersion in water - and subsequently ground to cement fineness. Slag cement is hydraulic and can be added to cement as an SCM.
- **Silica fume.** A finely divided residue resulting from the production of elemental silicon or ferro-silicon alloys that is carried from the furnace by the exhaust gases. Silica fume, with or without fly ash or slag, is often used to make high-strength concrete.

Source: Portland Cement Association (PCA)

BioChar

Waste-derived carbon-based material that sequesters carbon.

Can be generated from wood material or bio solids…even manure!



From a report, "Biochar-augmented carbon-negative concrete" published in Chemical Engineering Journal in March of 2022.

BioChar

INTERESTING ENGINEERING

This eco-friendly concrete uses biochar to suck out carbon dioxide

The biochar was able to suck up to 23 percent of its weight in carbon dioxide from the air.

Loukia Papadopoulos
Created: Apr 19, 2023 09:00 AM EST

INNOVATION

Concrete.

BanksPhotos/iStock

Stay ahead of your peers in technology and engineering - The Blueprint

Email address

Join

By subscribing, you agree to our Terms of Use and Policies You may unsubscribe at any time.

Washington State University (WSU) researchers have engineered a carbon-negative, environmentally friendly concrete that is nearly as strong as regular concrete by infusing regular cement with biochar, a type of charcoal made from organic waste.

The biochar was able to suck up to 23 percent of its weight in carbon dioxide from the air while still achieving a strength comparable to ordinary cement.

"We're very excited that this will contribute to the mission of zero-carbon built environment," said Xianming Shi, professor in the WSU Department of Civil and Environmental Engineering and the corresponding author on the paper.

More than 4 billion tons of concrete are produced every year globally and cement production is thought to be responsible for about 8 percent of total carbon emissions by human activities worldwide.

SEE ALSO

Calcium Carbonate Aggregates

- Synthetic limestone made from industry CO2 and calcified water.
- Will continue to reabsorb CO2 throughout its life.
- Can bring about as much as a 40 percent reduction in CO2.
- Working to scale up.
- Blue Planet

Calcium Carbonate Aggregates

"Blue Planet System's idea is to capture carbon dioxide emissions from power plants and other sources, and use the CO2 to manufacture the aggregate which goes into making concrete. If successful, the firm claims that the end result is a double win: first, carbon dioxide from the production of energy is diverted from being emitted into the atmosphere, and is instead sequestered; and second, the synthetic aggregate results in reduced emissions that would have been associated with the production of cement and concrete by conventional means.

As for the cement, [Blue Planet] has pioneered a way to manufacture cement which mimics the way that corals build reefs. Cement and coral reefs are both limestone, and therefore the issue involves how to make limestone in a way that does not produce large emissions of carbon dioxide. Thus far, corals do it successfully, and humans do not. Limestone is calcium carbonate, which can be produced as a chemical combination of carbon dioxide, oxygen, and calcium."

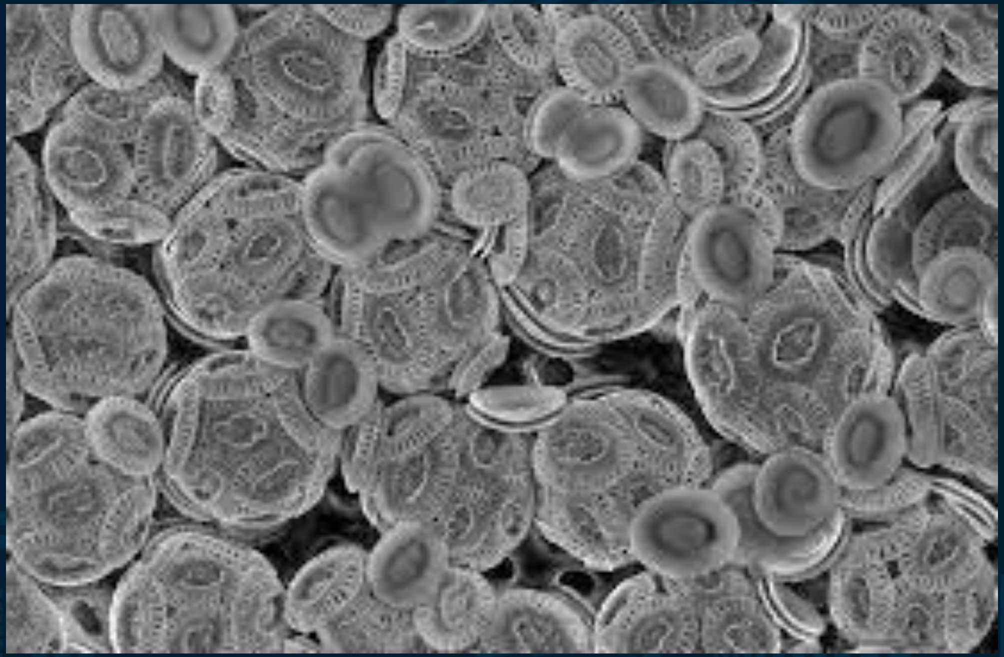
-- "Cement, Concrete, Blue Planet, And Climate Change: Taking Lemons And Making Lemonade," Forbes, March 31, 2022

Recycled Glass

- New York-based Urban Mining Industries has been advancing a new use for recycled glass in the form of Pozzotive, a ground glass pozzolan used in concrete production.
- Ground glass can assume cement-like qualities when it reacts with a combination of water and cement.
- In most mixes, Pozzotive can replace 20 or 30 percent of cement.

Microalgae

- That’s right. Algae.
- To make portland cement limestone is extracted from large quarries and burned at high temperatures, releasing large amounts of carbon dioxide
- Some species of single-cell calcareous microalgae can biololgically grow limestone through photosynthesis, just like growing coral reefs.
- Creates a net carbon neutral way to make portland cement



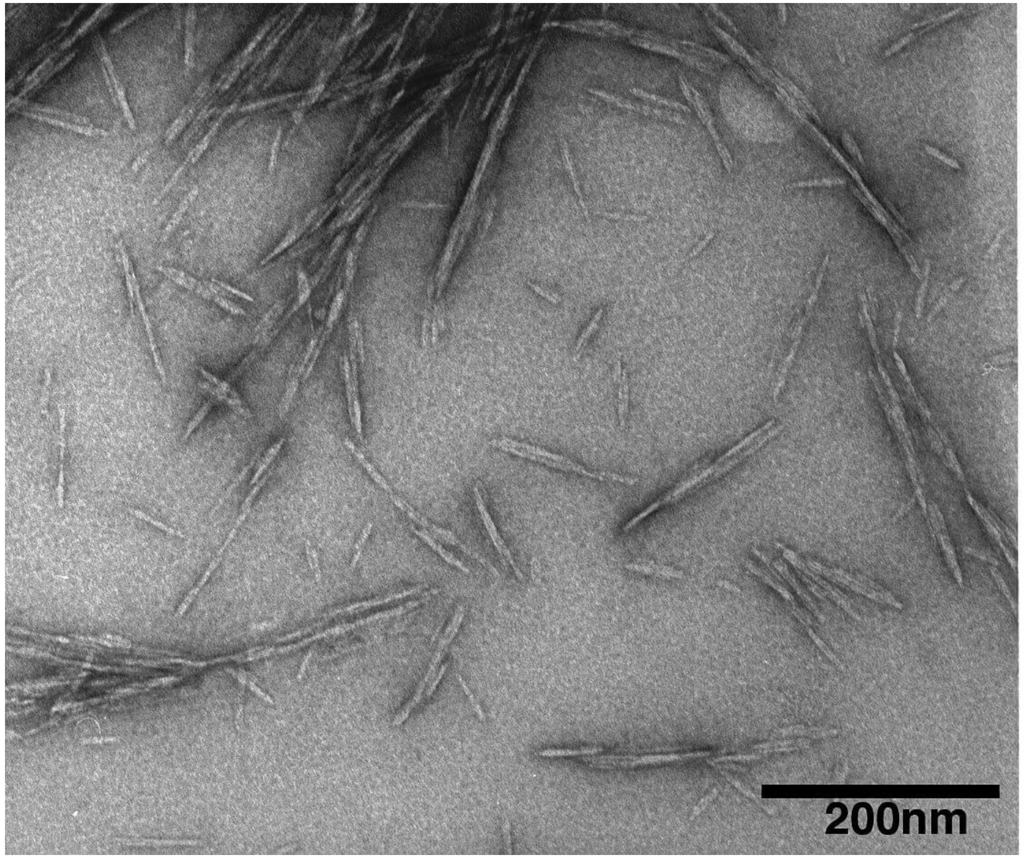
Microalgae

- Research being done by University of Colorado, Boulder and University of North Carolina Wilmington.
- 1 to 2 million acres of open pond systems would be needed to grow enough microalgae-producing limestone to meet the demand for cement production (about 90 million tons annually) in the United States.
- For context, about 100 million acres of land is used to grow corn in the U.S.
- Would need 1 percent of that grow enough algae-generated cement.

Cellulous Nanomaterials (CN)

“Cellulose nanomaterials (CNs) are a new class of cellulose particles with properties and functionalities distinct from molecular cellulose and wood pulp, and as a result, they are being developed for applications that were once thought impossible for cellulosic materials.” – U.S. Forest Service

The nanoparticles are small, significantly smaller than the cement particles, so when they mix with the cement particles, they’re small enough that they absorb to the surface of the cement particles, strengthening the final product.



Cellulous Nanomaterials (CN)

Material strength increased by 20 percent and greenhouse gases cut by 1/3.

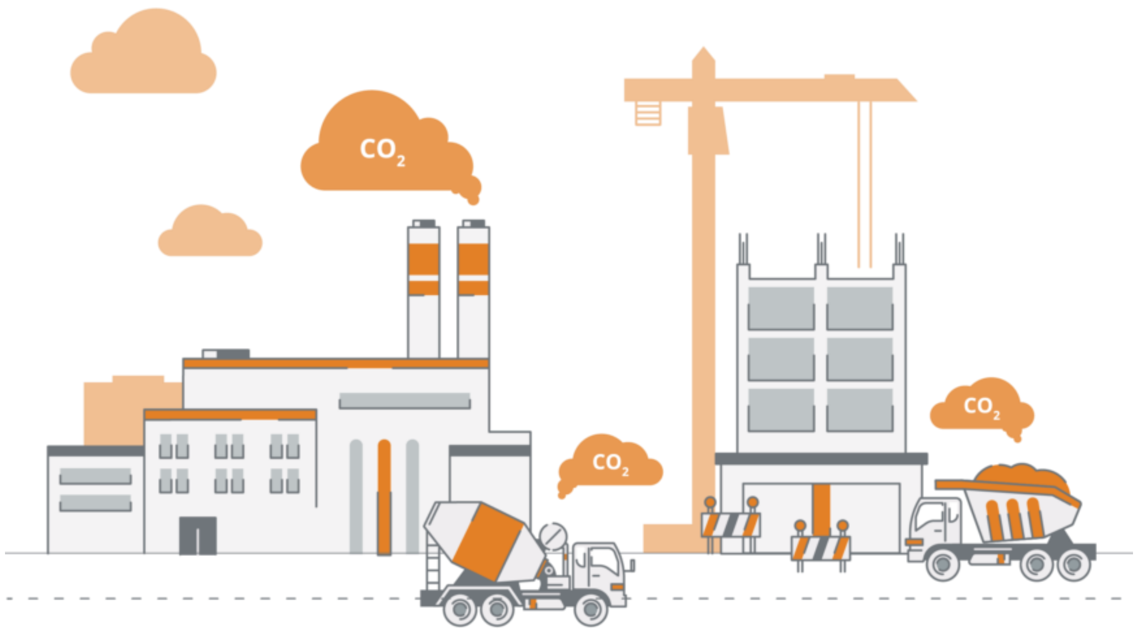
Cellulose fibers in concrete increase freeze-thaw durability and provide a good finished surface

Used to improve impact resistance and increase surface durability.

Recycled Aggregate

- Old, unneeded concrete can be recycled and used to create recycled aggregate.
- In most cases, recycled aggregate will be used as a subbase material, but it can also be paired with virgin materials and reused as an aggregate in new concrete.
- Recycled concrete aggregates contain not only the original aggregates, but also hydrated cement paste. This paste reduces the specific gravity and increases the porosity compared to similar virgin aggregates. Higher porosity of RCA leads to a higher absorption.

Carbon Capture



Embodied Carbon
The emissions from manufacturing, transportation, and installation of building materials.

- New technology introduces recycled CO_2 into fresh concrete to reduce its carbon footprint .
- Once injected, the CO_2 undergoes a process and becomes permanently embedded.
- There are claims the technology can improve the compressive strength of precast concrete, which allows precast producers to further optimize their mix designs and reduce the carbon footprint of the precast products they provide.

Carbon Capture

- A team at Purdue proposes adding small amounts of nanoscale titanium dioxide to the cement paste that makes up concrete. The team found that titanium dioxide, a powdery substance known best for its uses in sunscreen, paints, plastics and food preservatives, enhances concrete's natural ability to sequester carbon dioxide.

- Researchers at the University of Michigan are working on composite that is engineered to react with CO2 and form minerals so that the greenhouse gas can be stored in the concrete rather than become a byproduct. Lab experiments showed that CO2 curing significantly improves the concrete's strength and durability, though results can vary depending on the concrete mixes and procedures.

Carbon Sink

- Around half of the carbon emissions from cement production are reabsorbed by the material when used in buildings and infrastructure, according to the latest IPCC climate report.
- The "cement carbonation sink" absorbs an estimated 20 million tonnes of carbon every year, according to an overlooked section of the report published earlier this month ahead of the Cop26 climate conference.
- "Direct CO2 emissions from carbonates in cement production are around four per cent of total fossil CO2 emissions," says the full version of the Sixth Assessment Report from the Intergovernmental Panel on Climate Change.
- "The uptake of CO2 in cement infrastructure (carbonation) offsets about one half of the carbonate emissions from current cement production."

Ultra-High Performance Concrete

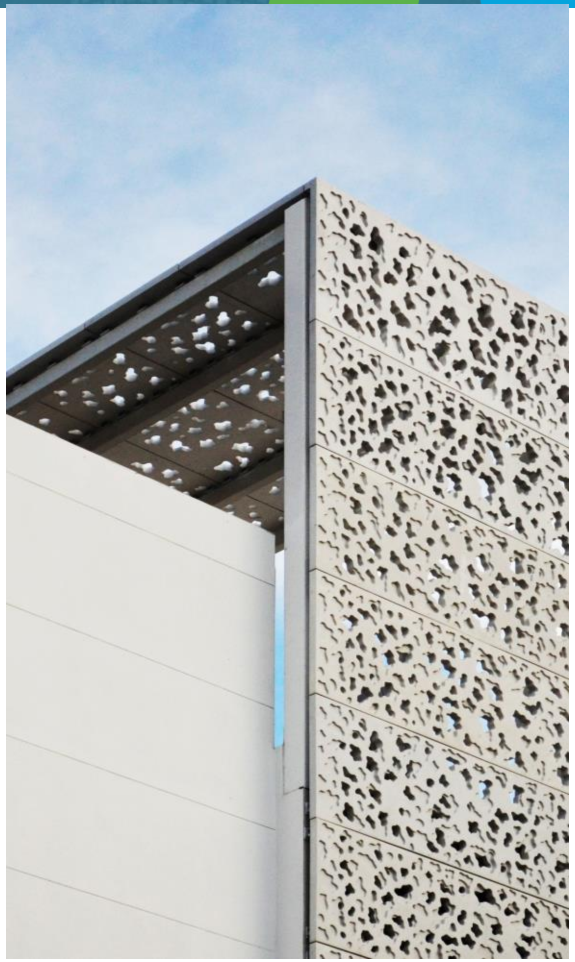
Ultra-High Performance Concrete (UHPC) is a cementitious, concrete material that has a minimum specified compressive strength of 17,000 pounds per square inch (120 MPa) with specified durability, tensile ductility and toughness requirements.

UHPC building and bridge members will use materials more efficiently while also being able to span farther. Lower consumption of construction materials will be good for the environment because of its potential to reduce carbon dioxide emissions.

Ultra-High Performance Concrete

Traditional Precast: 5,000 psi minimum strength and 700 psi flexural strength. Products include wall panels, column covers, self- supporting pieces and insulated/loadbearing walls, thickness ranges from 5” to 12”

UHPC: 14,000-17,000 psi minimum compressive strength, flexural strength is approximately 1,400 and greater. Products include rain screens, grand entrance cladding, urban furniture and interior solutions, thickness ranges from ½” to 3” maximum.



Ultra-High Performance Concrete

UHPC contributes to sustainable construction by doing more with less material.

Strong and Durable

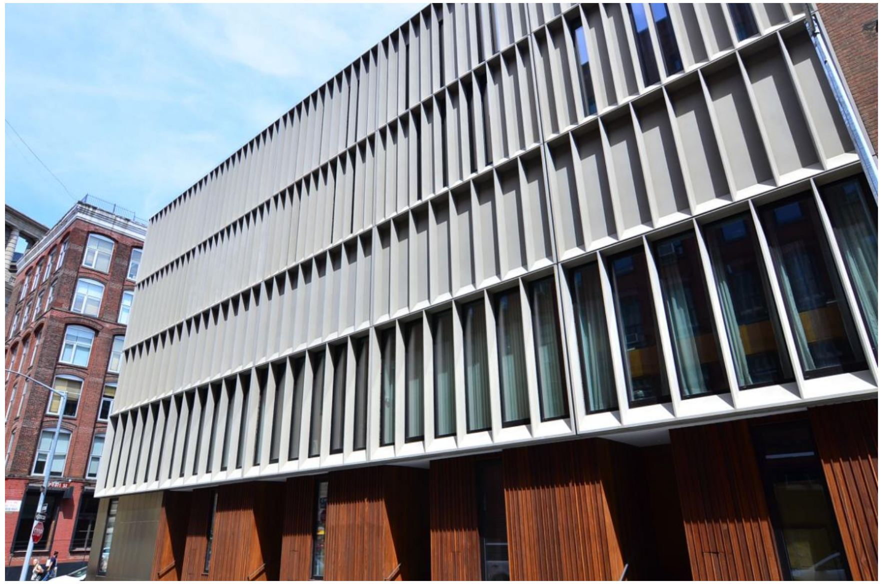
- Greatly reduced water-cement ratios
- 5X compressive strength, with higher density
- Longer life cycle

Sustainable

Reduction of materials and weight — up to 70%

Reduces overall carbon emissions from manufacturing / transportation

Reduces consumption of natural resources



HOW PRECAST **BUILDS**®

Operations

PCI
Precast/Prestressed Concrete Institute

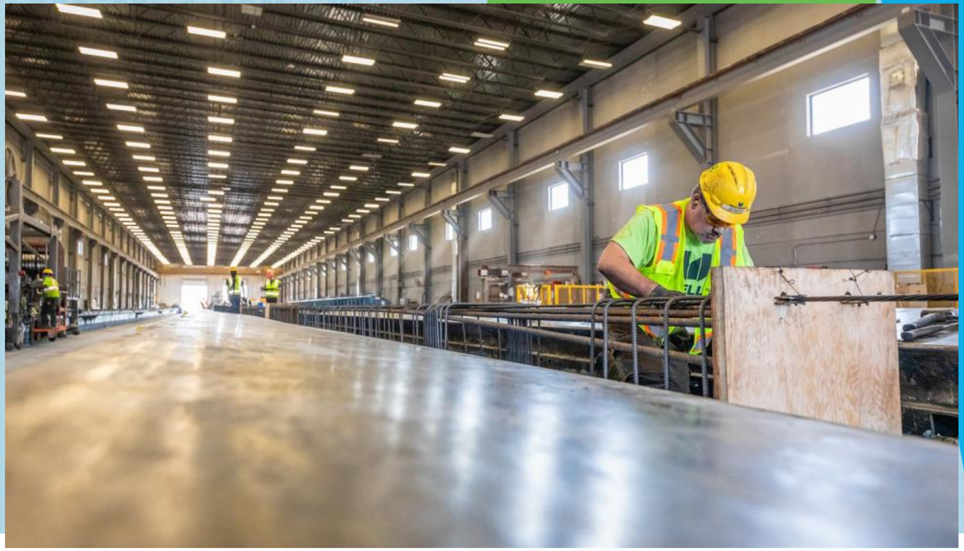
Environmental Product Declarations

1. EPDs are being developed, both industrywide and company or product specific.
2. Collaboration between industry and government is key.
3. We are all working toward more sustainable, resilient structures.

Plant Performance

Many individual companies throughout different segments of the concrete industry are showing leadership and finding ways to improve their facilities and processes.

Goals and techniques vary, but following are examples of what some producers in the precast industry are doing.



Wells

- Based in Minnesota, with plants in Colorado, Illinois and Wisconsin.
- Actively working on energy conservation, carbon reduction, sustainable building design and waste management methods across all its facilities.
- Production facilities use fly ash, which reduces the amount of embodied carbon in their concrete mix by up to 10 percent.
- Developing and sharing EPDs.

Wells

- Retired three outdated production facilities, replacing them with new sustainable precast manufacturing facilities that are more energy efficient and reduce raw material waste.
- Work with carbon capture firms to mineralize and insert reclaimed gas into the concrete mix during production.
- New cladding system, Infinite Facade, uses approximately 65 percent less concrete than typical precast spandrel construction in multi-story buildings.
- Lighter weight panels also help reduce the size of the structure needed to support the exterior enclosure, further reducing the overall embodied carbon impact.

Knife River

- Ultramodern concrete batch plant with better controls allowing for optimized mix designs to reduce carbon footprint by as much as 20 percent on certain mixes.
- Utilization of an electric concrete delivery system eliminates the use of diesel engine driven delivery equipment.
- Roof designed to support future utilization of solar power.
- Site is laid out to minimize wasted transportation and accommodate long-term growth of the business.

Knife River

- Headquartered in North Dakota with locations in 14 states.
- Currently building a new state-of-the art precast manufacturing facility in Washington.
- New facility is seeking Concrete Sustainability Council (CSC) certification.
- Zero untreated water emissions from process waters.
- Wasted concrete will be recycled on site.

Metromont

- Minimize building material waste with efficient production processes where 2% waste is created and up to 95% of that waste is reclaimed and/or recycled into other products.
- Recycling of all concrete slurry water and reclaiming of aggregates is becoming common in concrete man y manufacturing facilities.
- Metromont has one of the world's largest recycling and reclaiming processes at its Greenville, Hiram, Richmond and Florida manufacturing facilities.

Metromont

- In one plant alone, they recycle approximately 6.3 million gallons of water per year, decreasing its water bill by more than 70%.
- Typically 80-90% of materials are extracted, manufactured, delivered and installed within 100 – 500 miles of all project sites.
- By using non-corrosive C-GRID® carbon fiber reinforcing in their Double Tees, weight of the components are reduced by up to 8%.

Concrete Industry Resources

The Precast/Prestressed Concrete Institute (PCI), **pci.org**

National Ready Mixed Concrete Association (NRMCA), **buildwithstrength.com**

NEU: an ACI Center of Excellence for Carbon Neutral Concrete, **www.neuconcrete.org**

Summary

Concrete is a durable, efficient material that inherently provides the versatility and resiliency needed to meet the multi-hazard requirements and long-term demands of high performance structures.

Beyond excellent lifetime performance, the concrete industry is innovating and working tirelessly to reduce it's carbon impact in the short term. Promising new techniques and technologies enable us to build for tomorrow.

Questions?

PCI Precast/Prestressed Concrete Institute | HOW PRECAST BUILDS®

Thank you!

Precast/Prestressed Concrete Institute

HOW PRECAST BUILDS®