PROMETHEUS
MATERIALS

Inspired by Nature

A Deep Dive into the Future of Bio-Concrete

PRESENTED TO

ACI Conference 2024

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ABOUT US

Leadership – Scientific Expertise Coupled with Business Acumen

Loren Burnett

President, CEO and Co-founder

Serial entrepreneur with 30+ years leadership of technology companies – founded 6 companies with 5 exits, generating $375M in shareholder gains, raised $190M in funding, led 17 M&A transactions and 1 IPO filing

Leo Atencio

Director of Product Management

Leader in sustainable design products and construction with 25+ years experience in concrete building materials

Stephen Bell, PhD

Director of Biotechnology

Passionate, metric-driven scientist with interests and training that intersect biology and chemistry

Vaughn Bigelow

Vice President of Manufacturing

25+ years experience in manufacturing and construction – including modular, scaled supply to OEM customers

John Hottle, PhD

Director of Research & Development

Leader in materials characterization, analytical research and product development

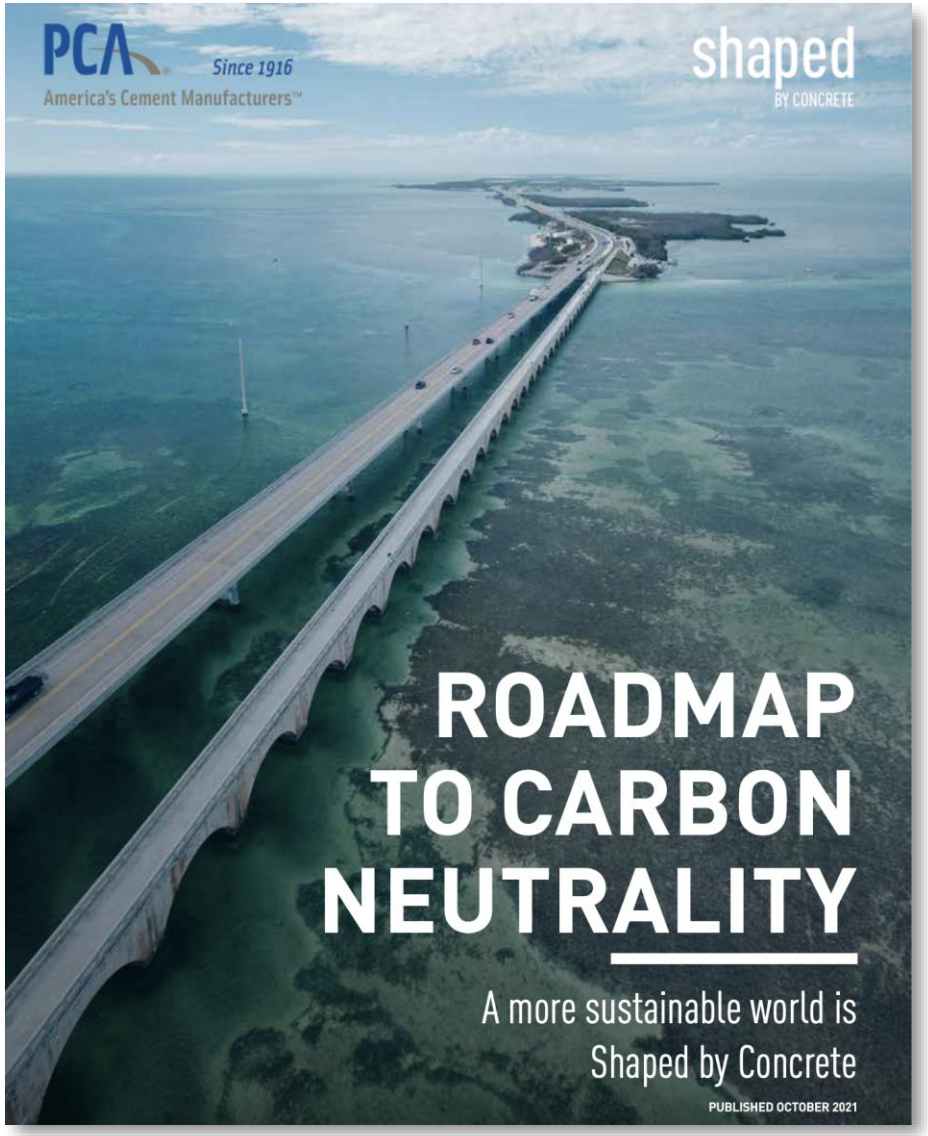
TRANSFORM

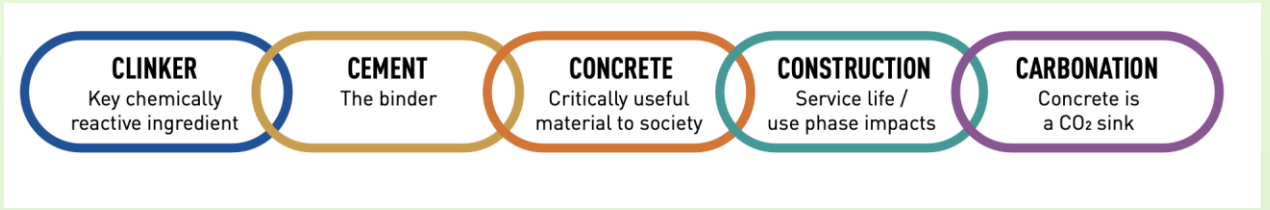
Sophisticated Solution for Carbon Neutrality

The Concrete Problem

- Second most used material – water #1
  - 8% of CO_2
  - 9% of industrial water
- 40% of CO_2 from built environment
- **Adding another 121 Billion Square Feet by 2050**
  - **Constructing a New York City every month for next 20 years**

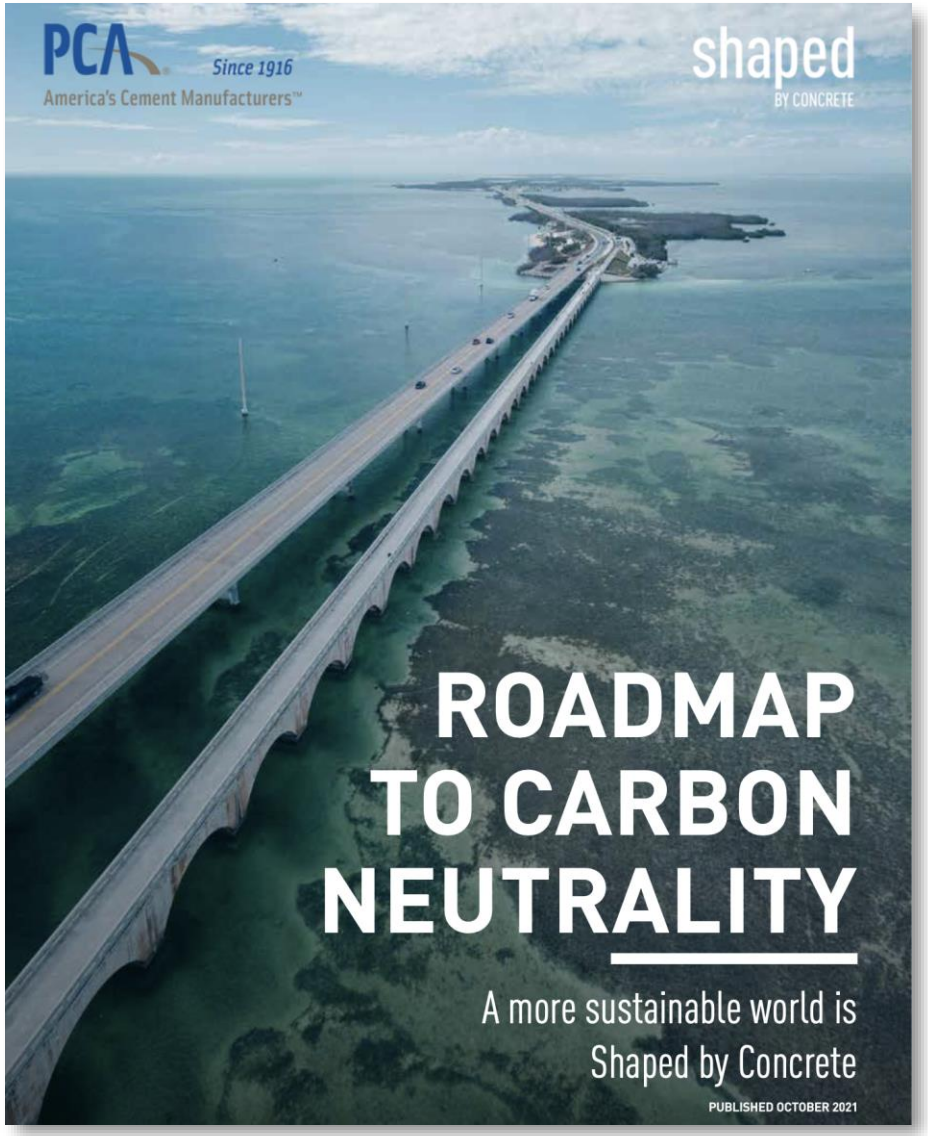
CO_2 Partnership





ROADMAP TO CARBON NEUTRALITY			
OUR VISION	OPPORTUNITIES & IMPACT	MONITORING PROGRESS	POLICY & SHARED ADVOCACY

CO_2 Partnership



CLINKER Key chemically reactive ingredient

CEMENT The binder

CONCRETE Critically useful material to society

CONSTRUCTION Service life / use phase impacts

CARBONATION Concrete is a CO_2 sink

Increasing supplementary cementitious materials

Cement includes clinker and finely ground limestone, inorganic processing additions, and precisely controlled amounts of sulfate. By decreasing the amount of clinker and increasing the limestone, inorganic processing additions, and other materials, the carbon intensity of cement can be lessened and still create a product that is equally durable and resilient and continues to meet the stringent quality standards required.

Currently, cements include less than 5% of these materials, and the industry is targeting increasing that ratio to 10% of these materials in 2030, 15% by 2040, and 20% by 2050.

Currently, cements have a clinker to cement ratio of more than 90%. The remaining material, gypsum, limestone, and processing additions can be partially replaced with supplementary cementitious materials (SCMs), which directly reduces the CO_2 that comes with clinker production – dropping the clinker amount 15% reduces the amount of CO_2 by 15%. SCMs include slag, fly ash, and silica fume. In many cases, these are industrial byproducts that would otherwise be landfilled and forgotten. Proper amounts of SCMs can improve durability and address the harmful chemical reactions caused by some aggregates.

Tomorrow's cements are targeting lower clinker to cement ratios with 0.85 by 2030, 0.80 by 2040, and 0.75 by 2050. Lowering clinker to cement ratios below 0.75 further requires consistent availability of SCMs.

CO_2 Partnership

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in 2030, 15% by 2040, and 20% by 2050.

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Innovation & Specification

Partnership

- Contingent on state and federal policy changes
- Specifications and standards changes and updates
  - Prescription to Performance (P2P)

EPA United States Environmental Protection Agency

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Environmental Topics | Laws & Regulations | Report a Violation | About EPA

Sustainable Marketplace: Greener Products and Services

CONTACT US

- Sustainable Marketplace Home
- Federal Purchasers
  - About the Environmentally Preferable Purchasing Program
  - Recommendations of Standards and Ecolabels
  - Framework for Assessing Standards and Ecolabels
  - Electronic Product Environmental Assessment Tool (EPEAT)
- Embodied Carbon
- Consumers
  - Identify Greener Products and Services
  - Why Buy Greener Products?
- Manufacturers
  - Selling to the Federal Government

Reducing Embodied Carbon of Construction Materials through the Inflation Reduction Act

What is Embodied Carbon? | Inflation Reduction Act | Grant Program | Tools & Resources

To further strengthen federal, state and local government efforts to reduce the embodied carbon of construction materials and products through Buy Clean programs, the Inflation Reduction Act passed by the U.S. Congress and signed into law by President Biden in 2022, includes six sections that address embodied carbon of construction materials:

- Sec. 60112 – $250 million to EPA to develop a program to support enhanced standardization, measurement, reporting and verification of embodied carbon of construction materials/products (grants, technical assistance, etc.).
- Sec. 60116 – $100 million to EPA to develop a program to identify and label construction materials/products that have substantially lower embodied carbon, in coordination with the General Services Administration (GSA) and the Department of Transportation Federal Highway Administration (DOT-FHWA).
- Sec. 60503 – $2.15 billion to GSA's Federal Buildings Fund.
- Sec. 60506 – $2 billion to the DOT-FHWA to reimburse/incentivize eligible recipients for the use of construction materials/ products that have substantially lower embodied carbon (as determined by EPA).
- Sec. 30002 – $837.5 million to Department of Housing and Urban Development (HUD) for direct loans and grants to improve climate resilience of affordable housing, including low-emission building materials/processes.

GSA U.S. General Services Administration

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Home › About us › Newsroom › News releases › GSA pilots Buy Clean Inflation Reduction Act Requirements for low embodied carbon construction materials

GSA pilots Buy Clean Inflation Reduction Act Requirements for low embodied carbon construction materials

May 16, 2023

Major milestone for industrial decarbonization advances eleven projects through materials with substantially lower levels of embodied carbon emissions

WASHINGTON — Marking a major milestone for the Biden-Harris Administration's industrial decarbonization goals, the U.S. General Services Administration today announced a pilot of new requirements [PDF - 88 KB] for the procurement of substantially lower embodied carbon construction materials in GSA projects funded by the Inflation Reduction Act. The requirements [PDF - 145 KB] were developed with market insights gathered from domestic manufacturers, local suppliers, small businesses, and environmental and labor groups. They advance President Biden's federal sustainability goals and efforts to strengthen American leadership in clean manufacturing and jobs.

The Inflation Reduction Act provides $3.375 billion for GSA to invest in federal buildings to help reduce carbon emissions and catalyze innovation. This Act includes $2.15 billion to procure low embodied carbon materials for construction and renovation projects. In support of the Biden-Harris Administration Federal Buy Clean Initiative, these investments are helping GSA leverage its purchasing power to spur markets for products that have substantially lower levels of embodied greenhouse gas emissions associated with their raw materials, transportation, and manufacturing — all of which occurs before GSA purchases the products. This pilot will help achieve President Biden's federal sustainability goals, including a net zero emissions federal building portfolio by 2045, and net zero emissions procurement by 2050, while supporting good American manufacturing jobs.

"Today's announcement marks a major step forward in our efforts to use the federal government's buying power to catalyze innovation and strengthen American leadership in clean manufacturing and jobs," said **GSA Administrator Robin Carnahan**. "We look forward to acting on what we learn from this pilot to accelerate progress toward the government's urgent climate goals, and achieve the sustainability triple-win of good jobs, value for taxpayers and a healthier planet for future generations."

THE CITY OF NEW YORK
OFFICE OF THE MAYOR
NEW YORK, N.Y. 10007

EXECUTIVE ORDER NO. 23

September 22, 2022

CLEAN CONSTRUCTION

WHEREAS, Chapter 18 of the City Environmental Quality Review (CEQR) Technical Manual, entitled ""Greenhouse Gas Emissions and Climate Change," recommends reducing the carbon intensity of building materials; and

WHEREAS, the City of New York commits to reducing greenhouse gas emissions associated with the embodied carbon of building materials and construction equipment through city agency leadership as set forth in this Order; and

WHEREAS, the City of New York has the opportunity to lead the market development and uptake of low-embodied carbon and clean construction strategies through the incorporation of these principles into our publicly-funded projects;

COLORADO
Office of the State Architect
Department of Personnel & Administration

ENERGY & ENVIRONMENT PROGRAM POLICIES AND PROCEDURES

BUY CLEAN COLORADO ACT POLICY

Intent

The Buy Clean Colorado (BCCO) Act requires the Office of the State Architect (OSA) to establish a maximum acceptable global warming potential (GWP) limit for each category of eligible materials, which include asphalt and asphalt mixtures, cement and concrete mixtures, glass, post-tension steel, reinforcing steel, structural steel, and wood structural elements. These materials are the focus for Buy Clean Colorado due to their high carbon emissions impact and volume use in public projects and since reducing the impact of these materials will provide the greatest reduction of greenhouse gas emissions from State public projects. Through design optimization and responsible selection of materials, reduction of embodied carbon emissions from building materials can be accomplished.

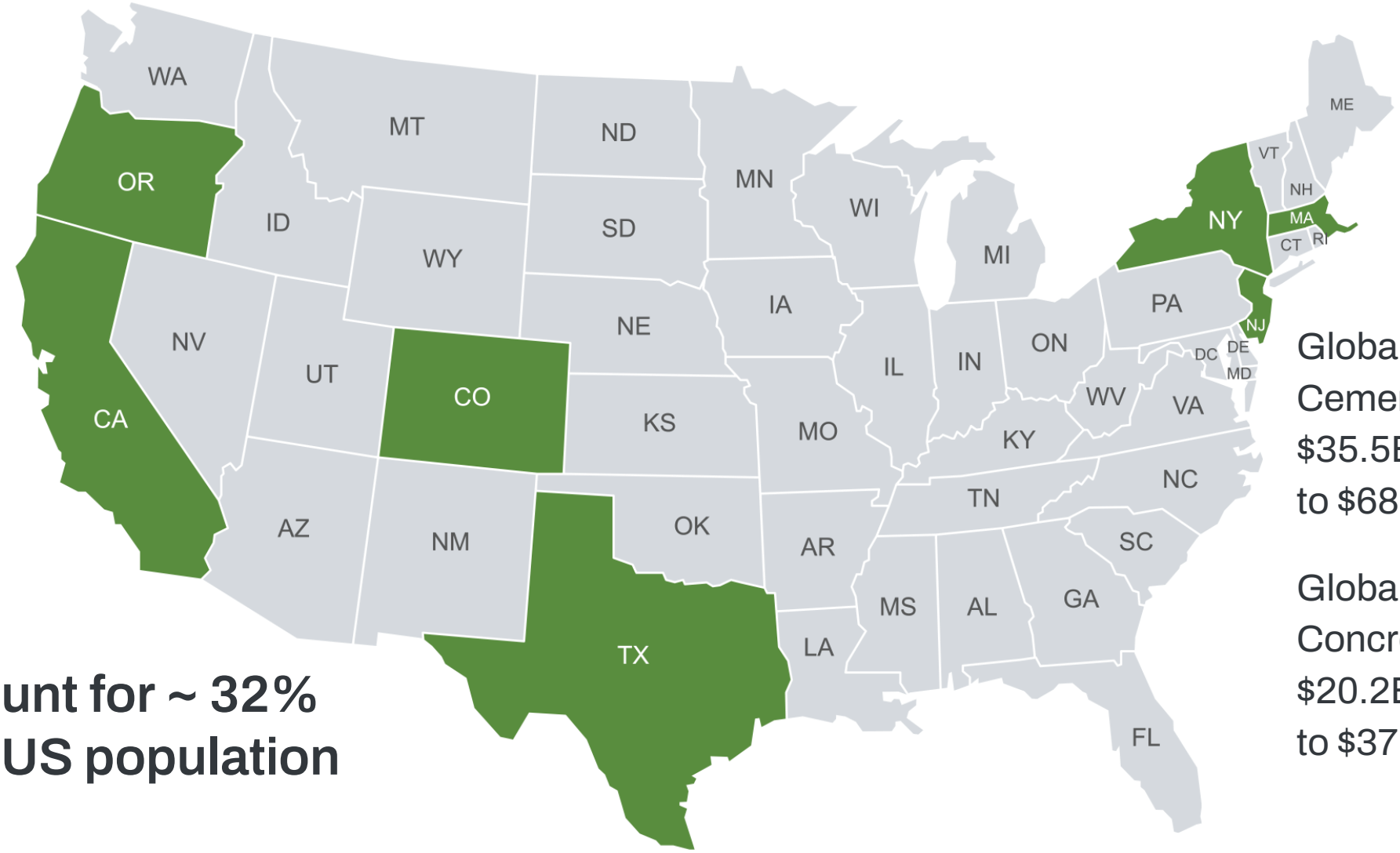
Meeting the BCCO Act does not alleviate any code or other requirements of a design engineer/architect.

Statutory Authority

Colorado Revised Statutes (C.R.S.):

C.R.S. 24-92-117	*Maximum global warming potentials for materials used in eligible projects – buildings – projects that are not roads, highways, or bridges*
C.R.S. 24-92-118	*Maximum global warming potential for materials used in public projects – road – highway – bridge projects*

CO_2 Emissions Legislation



Account for ~ 32% of the US population

Global Green Building Cement Segment: $35.5B (2023) growing to $68.7B (2030)

Global Green Building Concrete Segment: $20.2B (2023) growing to $37.59B (2030)

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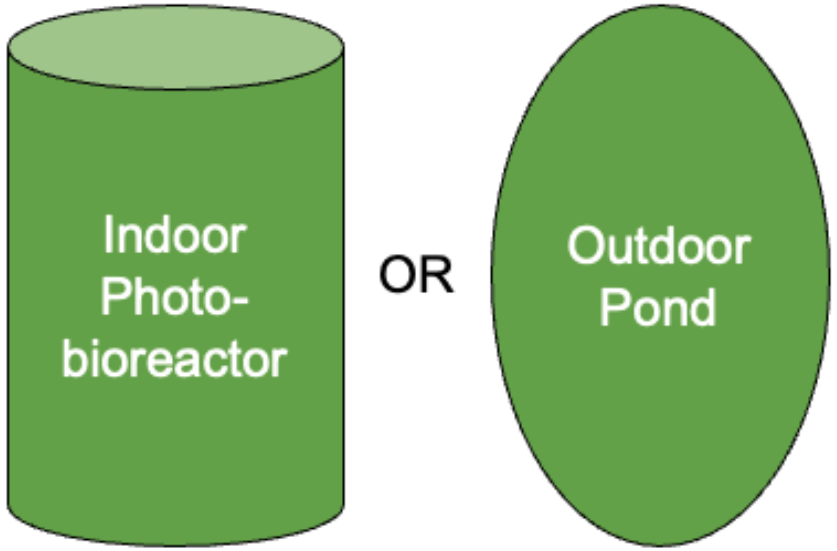
MICROALGAE TECHNOLOGY

Crafted By Nature

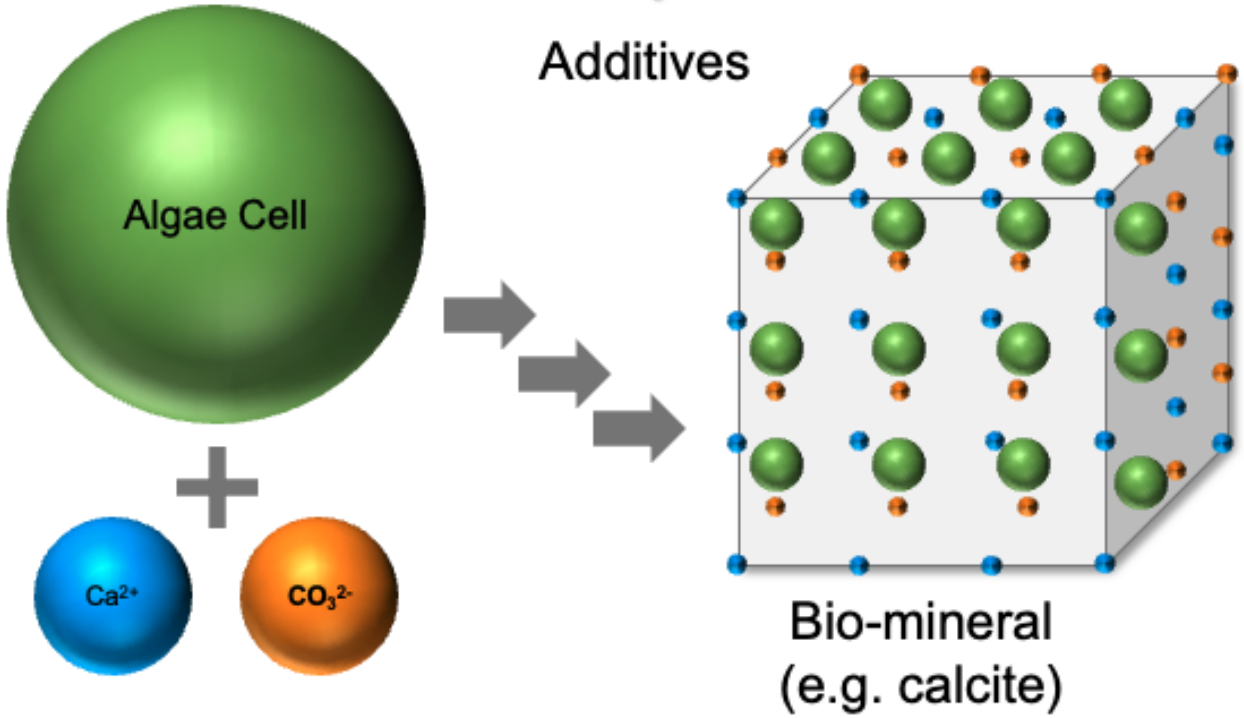
- **Microalgae**
- **Cultivation**
  - Photobioreactors
  - Open Raceway Ponds
- **Applications**
  - Animal Feed
  - Food
  - Bio-stimulants
  - Bio-packaging
  - Pharma & Nutraceuticals
  - Cosmetic
  - Biofuel

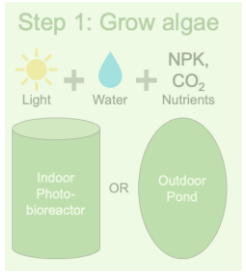
Step 1: Grow algae

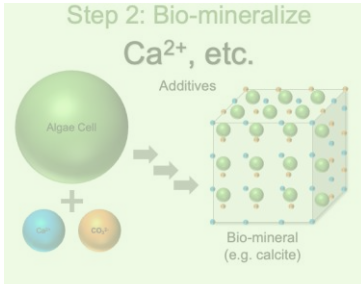


Step 2: Bio-mineralize

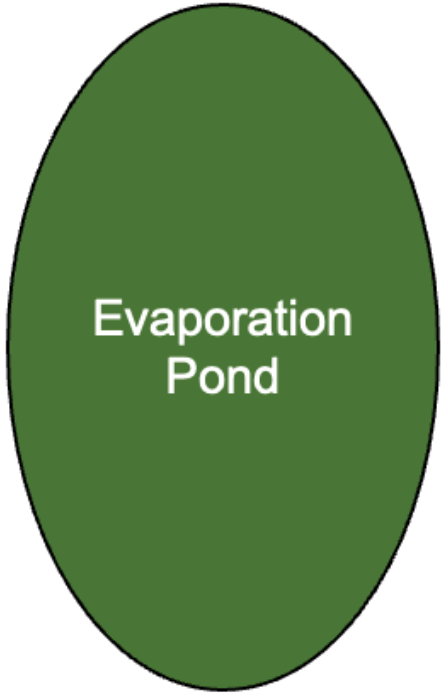
Ca^{2+}, etc.

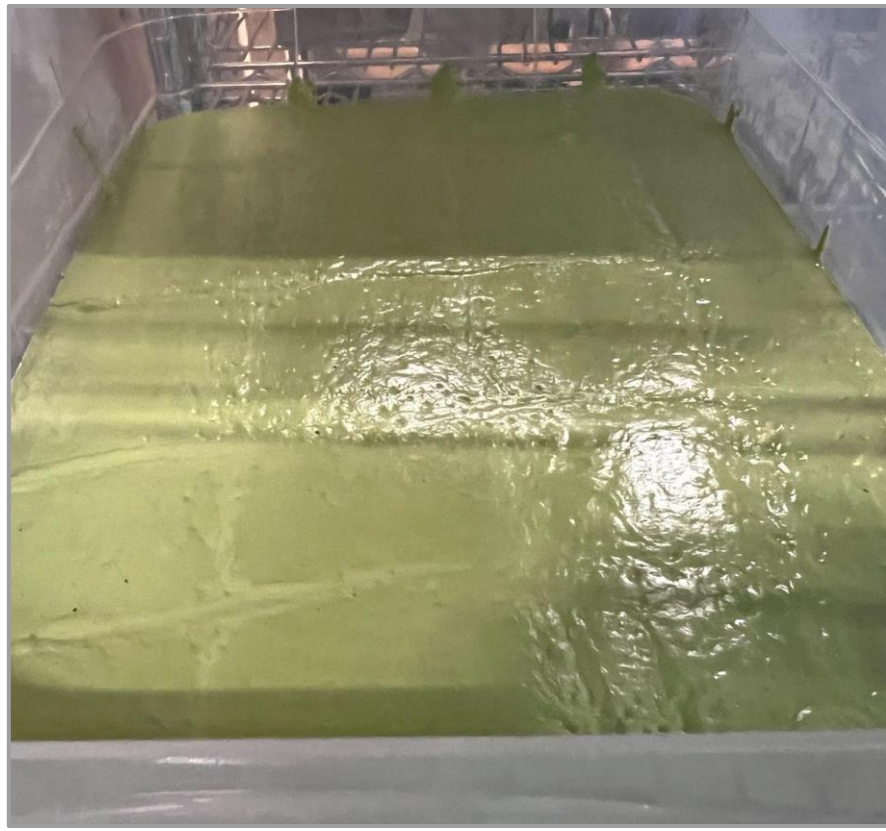




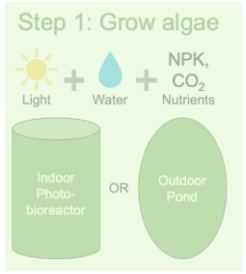


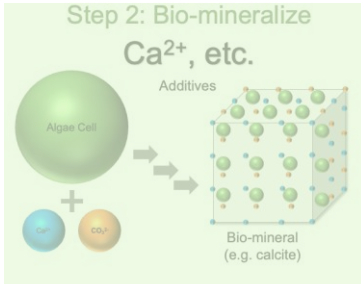
Step 3: Dry bio-minerals

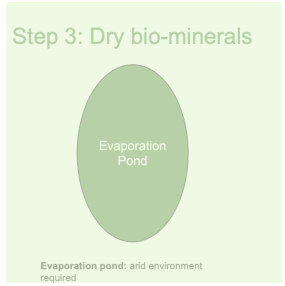




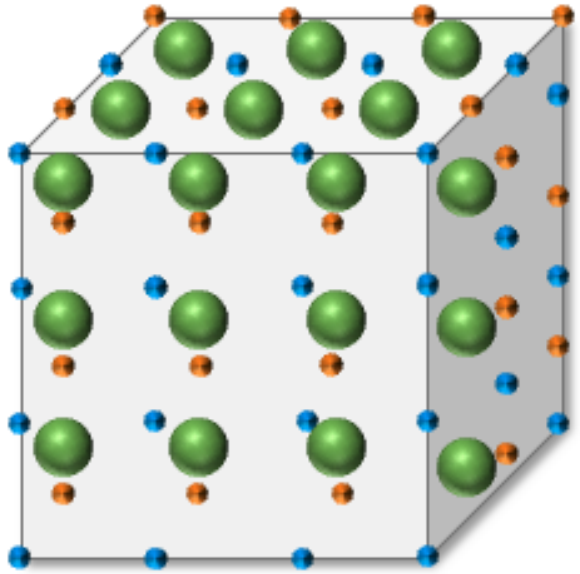
Evaporation pond: arid environment required







Step 4: Prepare bio-cement



Bio-mineral
(e.g. calcite)

+

Constituents

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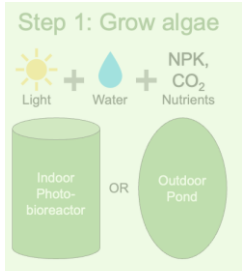

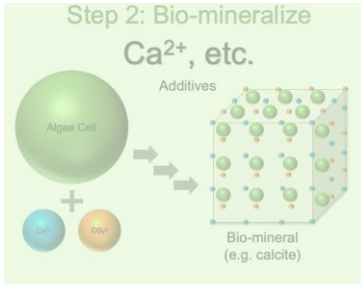

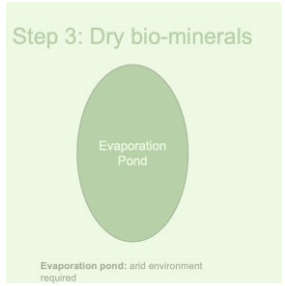

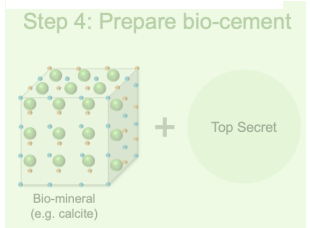

Step 5: Bio-cement into Bio-Blocks

Testing & Validation

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COMPLETED

ASTM C90: Load Bearing
- CTL Thompson

ASTM C423: Sound Absorption
- Johns Manville

ASTM C518: Thermal Conductivity
- Johns Manville

ASTM C1314: Prism Compressive Strength (solid fill)
- CMHA Lab

ASTM E136: Fire Combustion
- In-house testing

ASTM E84: Surface Burning Characteristics
- VTEC Labs

IN PROGRESS

ASTM C1314: Prism Compressive Strength (Hollow)
- CMHA Lab
- *In progress*

ASTM E518: Flexural Bond Strength (Hollow)
- CMHA Lab
- *In progress*

ASTM C666: Rapid Freeze/ Thaw
- Element Materials Tech.
- *In process*

ASTM E119: Fires Test of Building Materials
- VTEC Labs
- *TBD*

ASTM INTERNATIONAL

Prescription & Performance

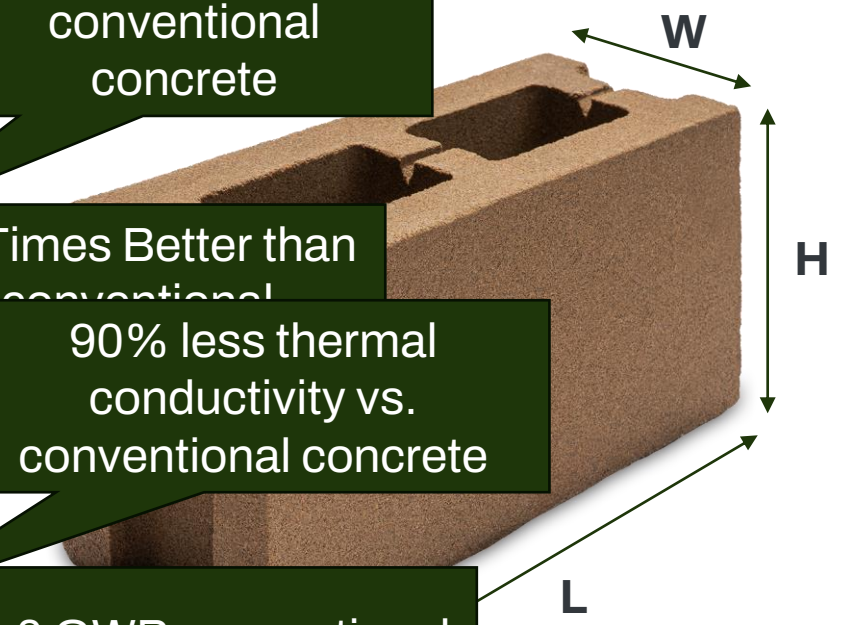
	PM Bio-Concrete
Compressive Strength (PSI)	2400-3500
Flexural Strength (PSI)	1200-1300
Density (pcf.)	104-108
Absorption (pcf.)	13-18
NRC (Noise reduction Coefficient)	0.60
Thermal Insulation R-Value	0.37R/inch
E84 Surface Burning Flame Spread & Smoke Development Index (SDI)	Flame A (0) SDI A (5)
Global Warming Potential (GWP) (kg CO_2- eq/ block)	(-) GWP
Enhanced Blast Resistance	✓
Eliminates Embodied CO_2	✓

2 Times Better than conventional concrete

12 Times Better than conventional

90% less thermal conductivity vs. conventional concrete

2.0 GWP conventional CMU



	PM Bio-Concrete
Block Width	8”
Block Height	8”
Block Length	16”

IMI Bio-block Walls

- IMI Demonstration
  (June 2023 | Bowie, MD)
- ~600 Bio-blocks- 3 Walls
  - Architectural Traditional and Complex Wall Design(s)
    - Designed by SOM
  - Constructability and Performance
    - Multiple tests performed by IMI
      - Type S Grout
      - Fasteners, Ties, Tapcons, Flashing, Self-Tapping Screws

INTERNATIONAL MASONRY INSTITUTE

SOM

CAB5 Bio-block Walls

- Chicago Architecture Biennial (September 2023 | Chicago, IL)
- ~ 600 Bio-blocks
  - Architectural Spiral Wall Design
    - Designed by SOM
  - Layout & Construction
    - Performed by IMI

INTERNATIONAL MASONRY INSTITUTE

SOM

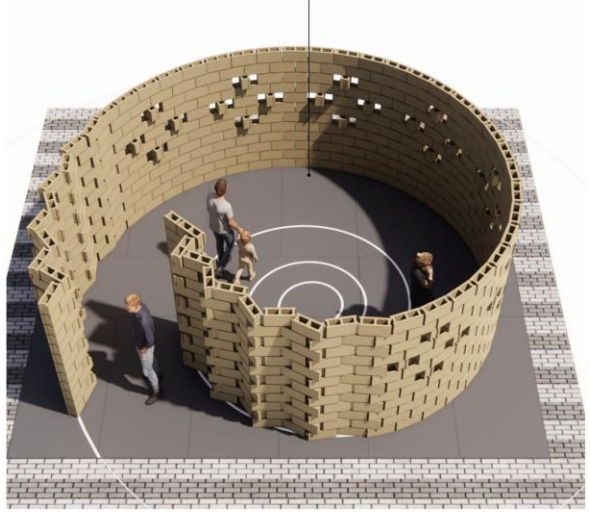
Pleated Ends

Overall Size and Geometry

Number of Blocks:	**539 blocks**
Min./Max Grout Thickness:	⅜" / 2 ¼"
Overall Dimensions:	**24'-0"x 20'-0"x 7'-4"**
Entrance:	4'-2"

Plan View

(1) 24'x 20'x 0-3/32" rubber underlay
(16) 4'x8'x0-1/2" tongue/groove plywood with 5/16" shop-beveled edge
Painted to match color/pattern provided by SOM



Perspective View

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DEVELOPMENT

Material	GWP kg CO_2 eq/ kg	Mix %		
Type 1L	.86	100%	70%	60%
PM Biomaterial	-3.11	0%	30%	40%

Test Wall

- In-house mock wall
- 6” W x 1.5’H x 4’L
- 40% Prometheus blended replacement (-3.08 GWP kg CO_2-eq/cy)
- 7-day 3,260 PSI
- 14-day 3,790 PSI
- 28-day 3,908 PSI

Next Steps

- **Research & Development**
  - Chemical and physical analysis
  - 3rd party testing and validation
- **Standards**
  - ASTM | ACI | ICC
- **Scalability**
  - Algae | Manufactured Goods
- **In-situ Demonstrations**
  - 3rd party collaboration

TRANSFORM

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Thank You

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