Adopting Innovations for Low-Carbon Concrete in Arizona

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Agenda

01 Concrete as a Solution to Sustainability

02 Policy Trends

03 Green Project Demand

04 EPDs

05 Levers for Cutting CO_2 Emissions in Concrete

06 Barriers & Opportunities

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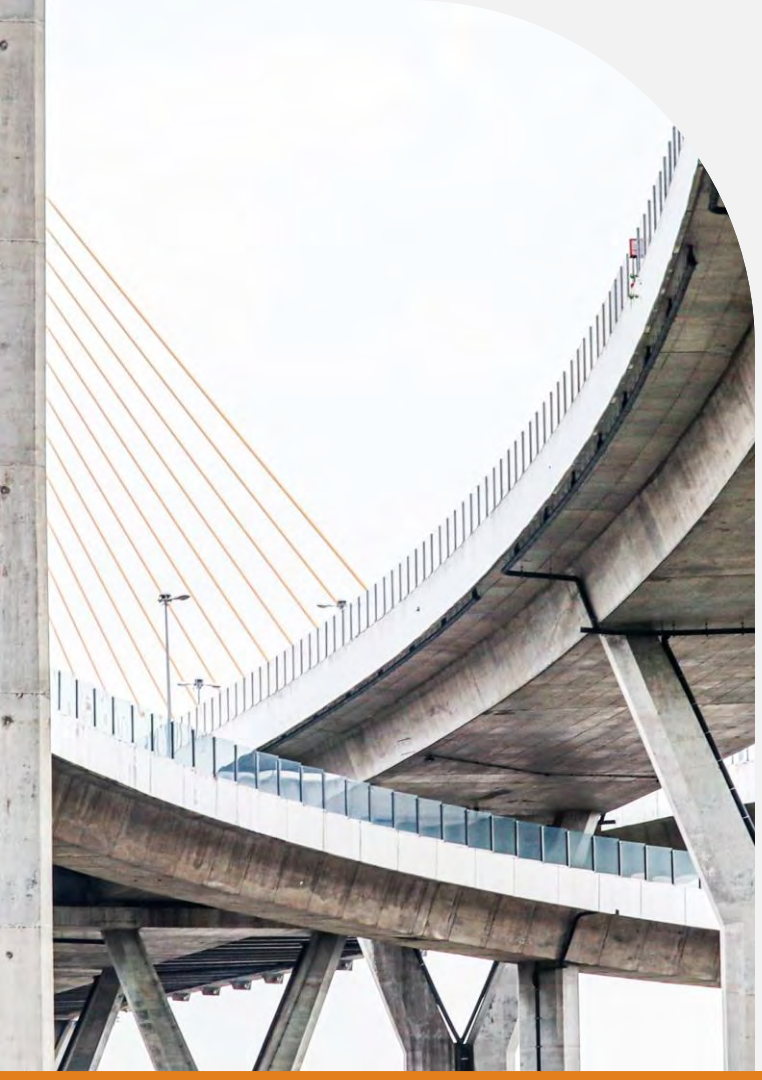


Concrete is the most abundant building material in the world.

As a result, cement production creates **~7%** of the world's CO_2 emissions and is one of the **largest contributors** to embodied carbon in the built environment.

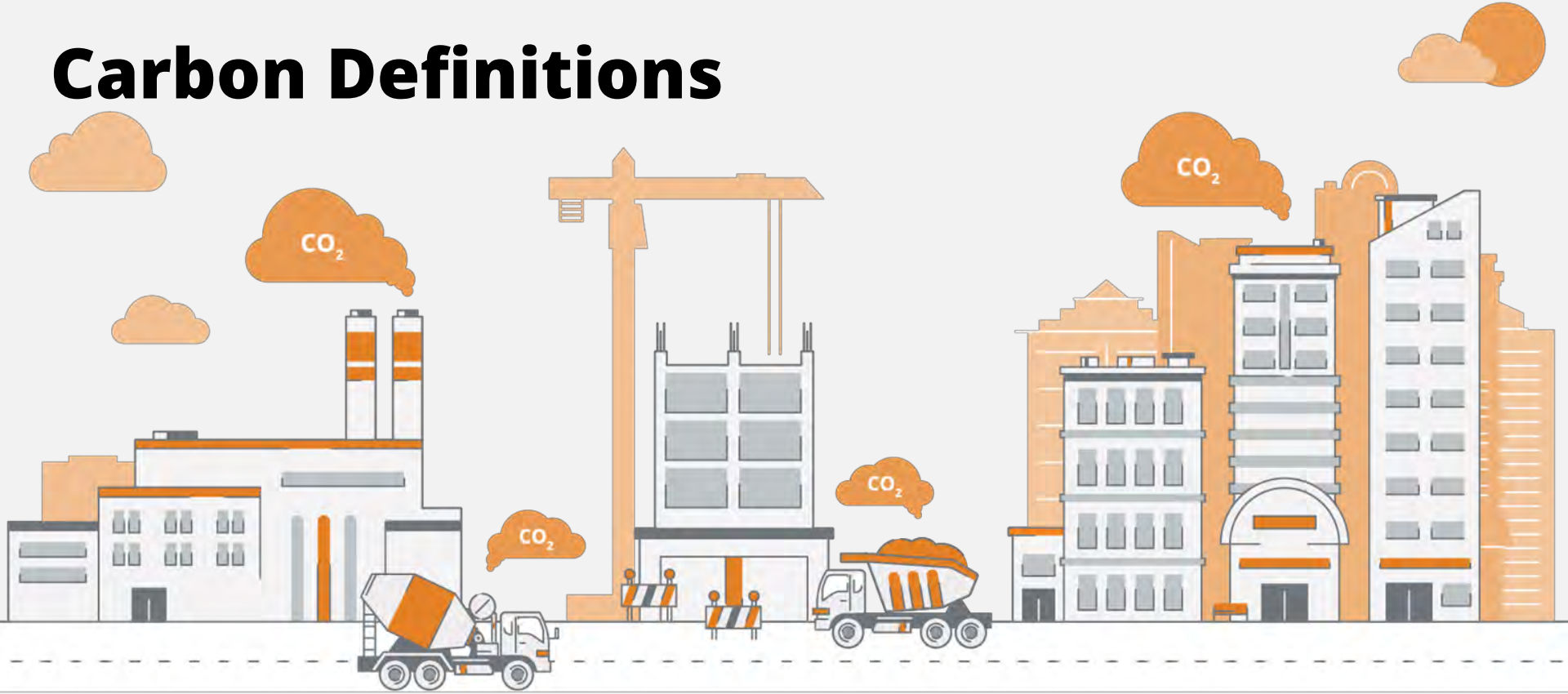
Did you know?

Concrete is uniquely positioned to respond to one of the most rapidly growing trends in today's construction.

Did you know?

Embodied carbon is expected to account for nearly 50% of the total carbon emissions from new construction over the next 40 years.

Carbon Definitions

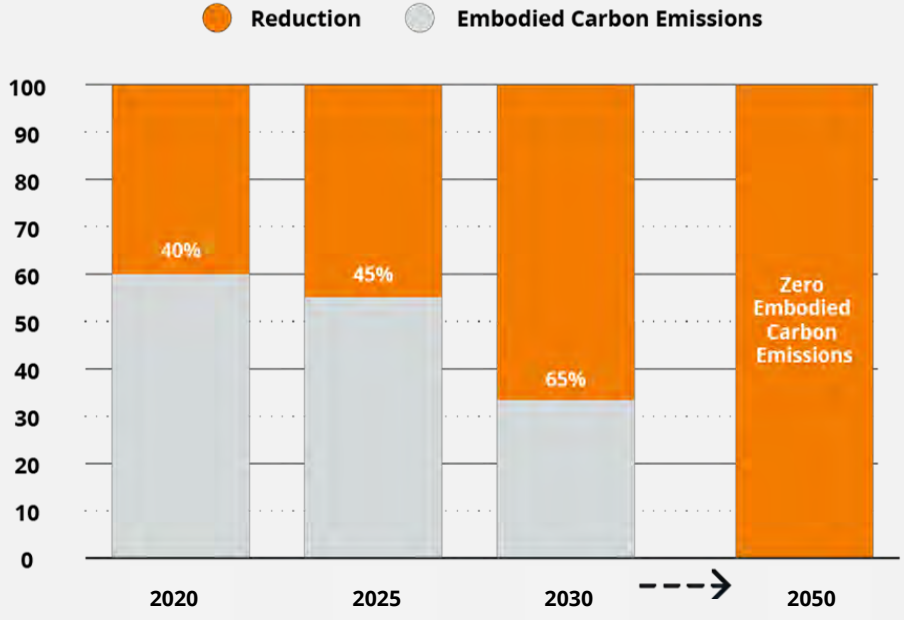


Embodied Carbon
The emissions from manufacturing, transportation, and installation of building materials.

Operational Carbon
The emissions from a building's energy consumption.

The Embodied Carbon Challenge

Architects, engineers, owners and governments aligned on a mission to reduce the carbon footprint of building materials and construction.



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Mission alignment with:

CLF Carbon Leadership Forum

SEI ASCE

architecture 2030

WORLD GREEN BUILDING COUNCIL

Federal Buy Clean Executive Order

Laws and Regulations

- January 1, 2023 - the United States federal purchasing agencies are required to obtain EPDs for concrete building materials used on federal projects.

Green Building as Growing Producer Opportunity

Key Market Trends

- High performance and green buildings are in high demand.
- Various government efforts and regulation mandates are driving green building in the US markets.
- The Global Green Building Materials market is projected to grow over 9% over the next 5 years (2022 - 2026)

EMBODIED CARBON PROJECT GROWTH

There are currently 584 active projects valued at over $18 billion dollars in the United States.

LEED PROJECT GROWTH

There are currently 52 active projects valued at over $3 billion dollars in Arizona.

Environmental Product Declaration (EPD)

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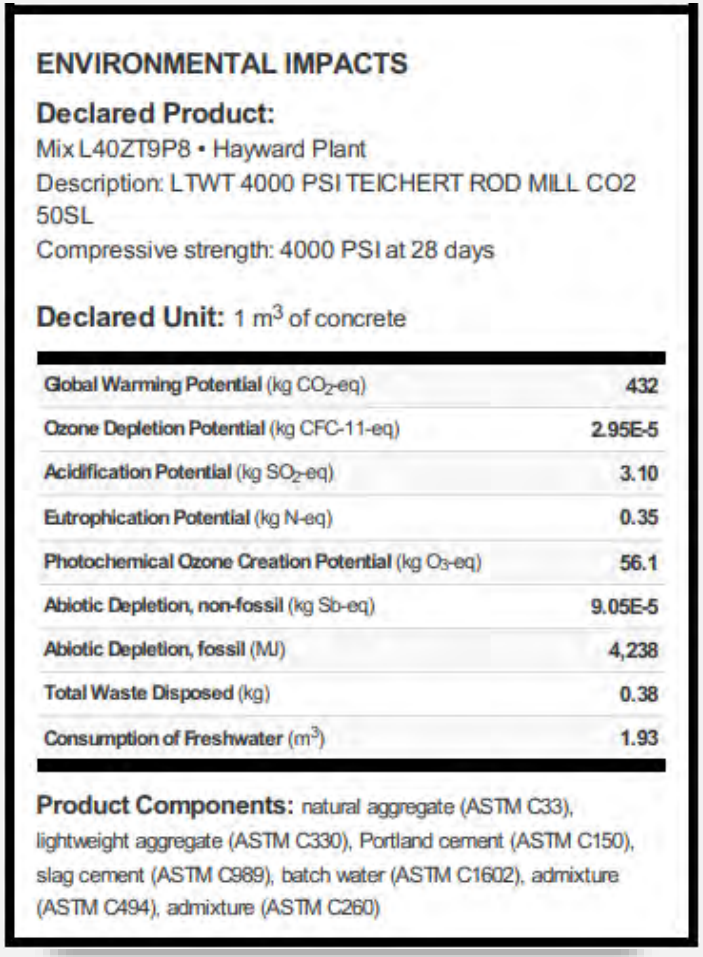
What is an EPD?

A third party-verified declaration of environmental impact

- Essentially like a nutrition label for concrete
- For a single mix design at a specific plant
- A Life Cycle Assessment (LCA) following the Product Category Rule (PCR) for construction material
- The environmental impact of this product from “cradle-to-gate”
- Valid for five years



ENVIRONMENTAL IMPACTS

Declared Product:
Mix L40ZT9P8 • Hayward Plant
Description: LTWT 4000 PSI TEICHERT ROD MILL CO2 50SL
Compressive strength: 4000 PSI at 28 days

Declared Unit: 1 m^3 of concrete

Global Warming Potential (kg CO_2-eq)	432
Ozone Depletion Potential (kg CFC-11-eq)	2.95E-5
Acidification Potential (kg SO_2-eq)	3.10
Eutrophication Potential (kg N-eq)	0.35
Photochemical Ozone Creation Potential (kg O_3-eq)	56.1
Abiotic Depletion, non-fossil (kg Sb-eq)	9.05E-5
Abiotic Depletion, fossil (MJ)	4,238
Total Waste Disposed (kg)	0.38
Consumption of Freshwater (m^3)	1.93

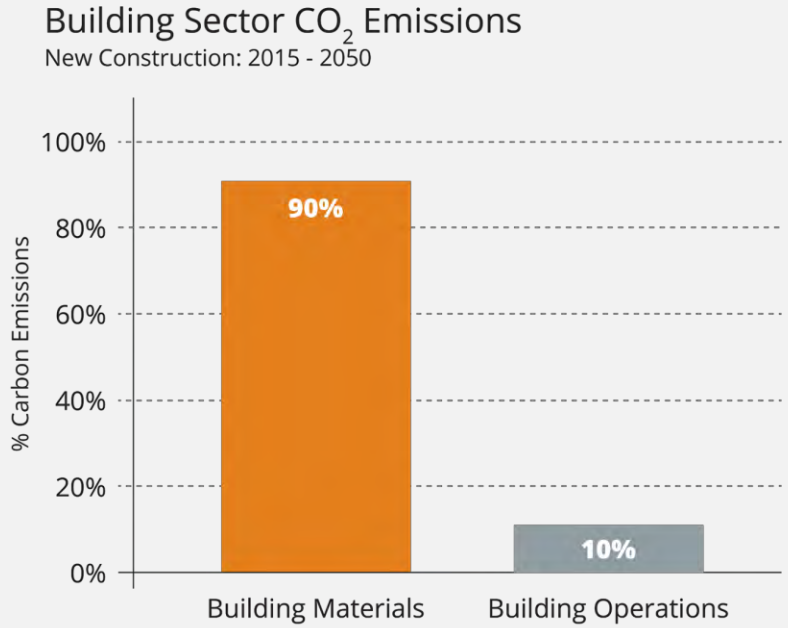
Product Components: natural aggregate (ASTM C33), lightweight aggregate (ASTM C330), Portland cement (ASTM C150), slag cement (ASTM C989), batch water (ASTM C1602), admixture (ASTM C494), admixture (ASTM C260)

EPDs IN ARIZONA

There are currently 18 EPDs spec'd on projects across Arizona. These projects are valued at $127 million dollars.

Why Do We Need EPDs?

- Growing demand for transparency of environmental impact of building materials
- Designers and architects are requesting EPDs more often
- New federal legislation in the US making EPDs a requirement (starting Jan. 1, 2023)



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Data Source: EIA (2011), Richard Stein, CBECS (2003), McKinsey Global Institute

How are EPDs Created?

1. Find the PCR
Find the correct Product Category Rule for Concrete to perform calculations and reporting.

2. Data Collection
Compile information on raw materials, suppliers, ancillary materials and other plant data.

3. Life Cycle Assessment
Create a life cycle assessment based on the data for each mix at a plant.

4. Create EPD
Use the life cycle assessment results to create an EPD.

5. Get EPD Verified
Have the results of the life cycle assessment and EPD verified by a third party.

Reducing Embodied Carbon in Concrete

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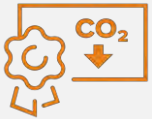
How Can We Reduce Embodied Carbon in Concrete *Now*?

Optimize
aggregate sources and combined gradations



Utilize low-carbon cement types

Incorporate
alternative and recycled materials

Shift
to performance-based specs

Permanent
CO_2 sequestration through CO_2 mineralization

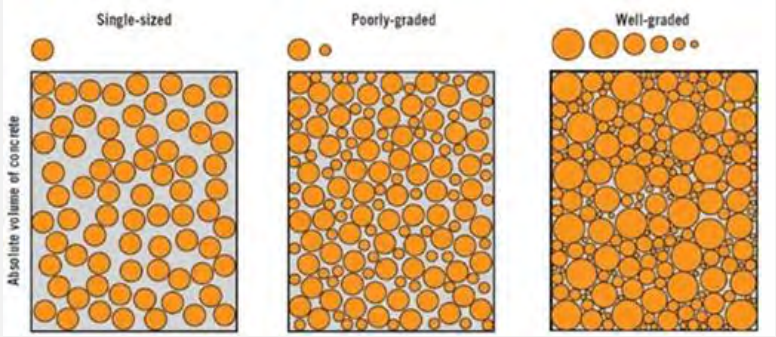
Optimize Your Aggregates

Optimized Gradation

- Incorporation of intermediate aggregate
- Focus on performance - workability, finishability, segregation, strength
- Reduce total paste fraction by 5-15%
- Reduced shrinkage and permeability
- Coarseness Factor (Shilstone), 0.45 Power Curve, Tarantula Curve (Ley)

Optimized Source

- Hard, durable aggregates will require less cement to hit compressive strength target
- Shop local to reduce emissions associated with trucking, railing, or barging aggregates long distances

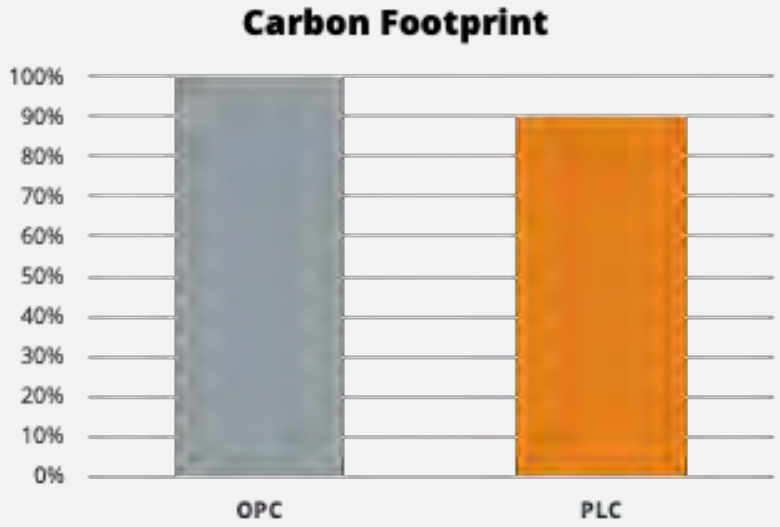


Utilize Low-Carbon Cements

- ASTM C595 Blended Cements
  - Limestone (IL), “PLC” or “GUL”
  - Slag (IS)
  - Pozzolan (IP)

- Alternate Cements
  - LC3 - 40% reduction
  - CSA - 60% reduction
  - Geopolymer cements - 70% reduction

- Less carbon-intensive manufacturing process = capitalize on lower CO_2e in mix design



Incorporate Alternative Materials

- Supplementary Cementitious Materials
  - Class F and C fly ashes
  - Class N “natural pozzolans”
  - Ground slag cement
  - Ground glass pozzolans
- Admixtures
- Recycled aggregate
  - Fresh returned concrete - captured through reclaimer
  - Hardened concrete - crushed and separated
  - Low risk / high volume applications
  - LEED - minimum 20% replacement
- Recycled water
  - C1602 process water
  - Slurry water

Shift Concrete Specifications

Types of Specifications

- **Prescriptive Specification:** recipe or how-to
- **Performance Specification:** end-goal but no method
- Hybrid options
  - Non conflicting requirements
- No “one spec fits all” approach, understand limits of each

NRMCA P2P Initiative

- 5 primary bottlenecks for reducing embodied carbon:
  - SIP 1: Maximum SCM content
  - SIP 2: Maximum W/CM
  - SIP 3: Minimum cementitious content
  - SIP 4: Type and characteristics of fly ash
  - SIP 5: Aggregate grading
- Establish applicable requirements
- Don’t eliminate specs that are working well

**SIP = Specification In Practice*

Permanent CO_2 Storage

CO_2 utilization technology for concrete

- CO_2 captured from industrial emitters
- Injected directly into fresh concrete
- CO_2 is permanently sequestered as a mineral
- Improved concrete performance allows for mix optimization, cost savings, and sustainable business growth

More About CarbonCure

CO_2 mineralization technology provider for concrete producers

Founded in
Halifax, Canada in 2012 by Rob Niven, MSc

More than
500 systems sold, 450+ plants currently supplying

Grand Prize Winner
of the NRG COSIA Carbon XPRIZE

Backed by
Breakthrough Energy Ventures, Amazon, Microsoft, Mitsubishi Corporation, Shopify, Stripe + more

CarbonCure's mission is to reduce 500 million metric tons of CO_2 emissions annually. That's equal to taking 100 million cars off the road.

Thomas CONCRETE · CEMEX · imi · OZINGA · ABC Ready Mix · CENTRAL · Robertson's

Thank You!

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