Carbon Sequestration and Concrete

Paul Seiler, Director of Technology

Beachwood, June 8, 2022

A brand of MBCC GROUP

The Problem

Second most used material in the world

> 8% global CO2 Emissions

> 4 billion tons

14 billion m^3

> 40% in Residential

~70% Population in Cities

Demand for concrete, and concrete products will continue to increase

Source: The GCCA 2050 Cement and Concrete Industry Roadmap for Net Zero Concrete report

Concrete as main building material

Concrete has several advantages to other building materials:

- Availability
- Durability
- Fire resistance
- Strength
- Resilience
- Versatility
- Place ability
- Thermal properties
- Carbon uptake
- Circular Economy

However... Producing the Raw Materials, transporting and placing is CO_2 intense!

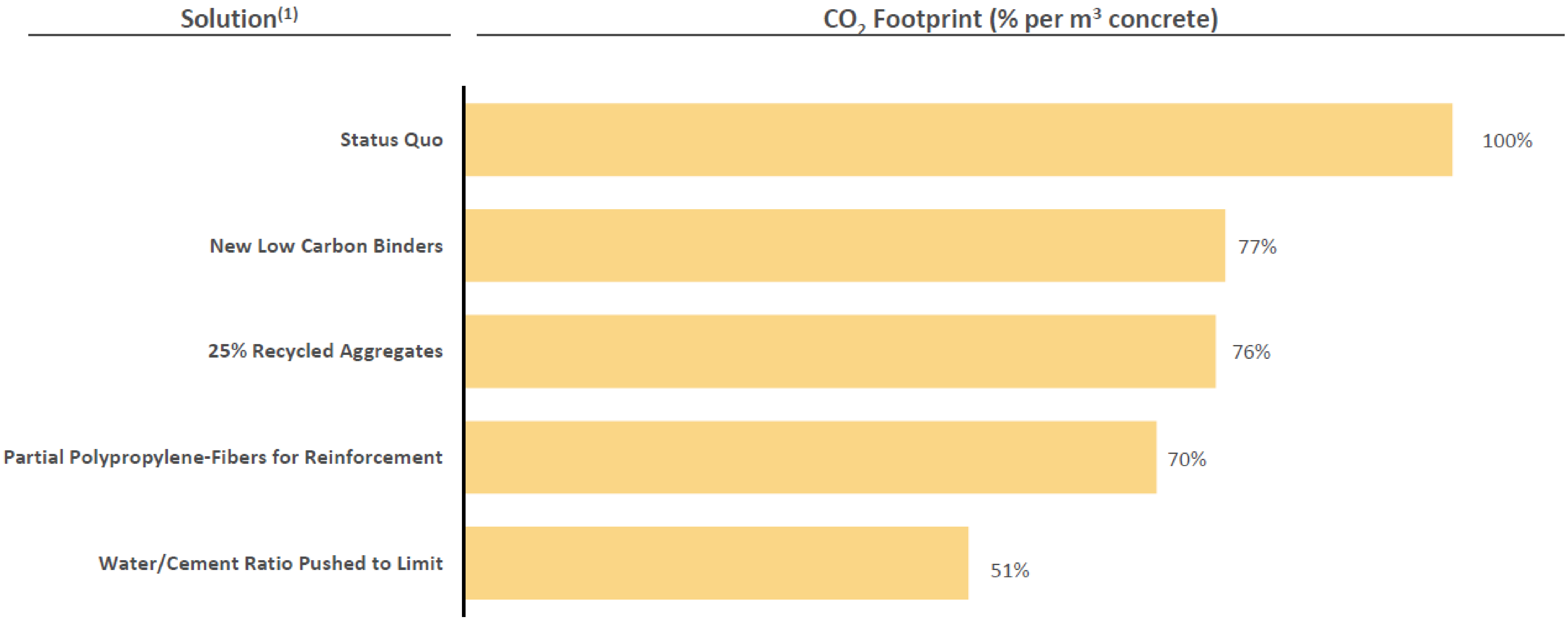
Source: The GCCA 2050 Cement and Concrete Industry Roadmap for Net Zero Concrete report

Reducing the CO_2 Footprint

Different Approaches:

- Material optimization:
  - Supplementary Cementitious Materials
  - Admixtures (focus on strength)
  - Recycled aggregates
  - Fiber reinforcement
- CO2 uptake during production and/or curing

Reducing the CO_2 Footprint



Highly Optimized Mix Designs

- One World Trade Center

Environmental Impacts	Environmental Savings
Energy usage	25,400,000 kWh (91,440,000 MJ)
Greenhouse gas emissions	34,800,000 lb CO_2eq (15,785,000 kg)
Water emissions	5,247,000 gal (19,862,000 L)
Solid waste	1,720,000 lb (780,178 kg)

Highly Optimized Mix Designs

- 432 Park Avenue

Climate Change

Water Emission

432 Park Avenue

Based on 90,000 yds^3 of concrete developed for four compressive strengths

Environmental Impact	Environmental Savings	
Energy usage	822,000 kWh	2,959,200 MJ
Climate change	21,120,000 lbs CO_2 eq	9,579,000 kg CO_2 eq
Water emissions	191,500,000 gal	724,900,000 liters
Solid waste	605,000 lbs	274,400 kg

Energy

Waste Reduction

This analysis compares the actual mix designs to reference concrete mixes with similar design requirements. The analysis was completed using the BASF Eco-Efficiency Analysis

Opportunity

Utilization of CO_2 during the manufacturing or curing process

- Thermodynamically favorable reaction mechanism
- Stable carbonates outlasting the life of the structure
- Growing concrete demand increases potential sequestration opportunities

Net CO_2 uptake benefits vary dramatically on how CO_2 is introduced to concrete

Source: Carbon dioxide utilization in concrete curing or mixing might not produce a net climate benefit; Dwarakanath, R et al. – Nature Communications

Opportunity

Utilization of CO_2 during the manufacturing or curing process

Added during Mixing

- Relies on CO2 capture, compression, storage and transportation
- Limited time contact between CO2 and concrete, with large amount lost to atmosphere.
- Can have impact on strength development

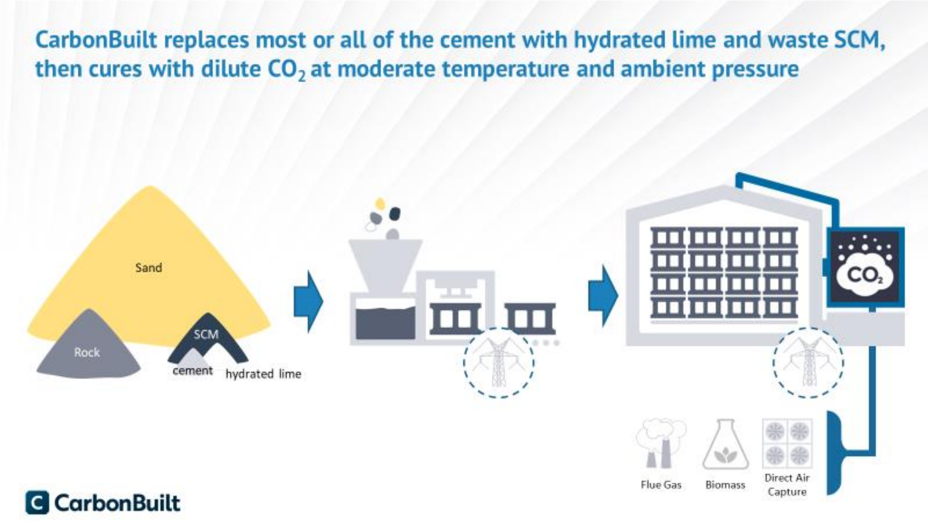
Added during Curing

- Redirects CO2 that would go to the atmosphere through a carbonation chamber
- Longer period of contact between concrete and CO2
- Directly contributes to the strength development (depending on the binder)

Studies demonstrate that CO2 uptake during curing is significantly higher than during mixing

Source: Carbon dioxide utilization in concrete curing or mixing might not produce a net climate benefit; Dwarakanath, R et al. – Nature Communications

Carbonation during Curing



Example: Portlandite-rich Systems for Concrete Block

Materials:

- Minimal (if any) amount of OPC
- Higher levels of Calcium Hydroxide
- Supplementary Cementitious Materials
- Admixtures

Process:

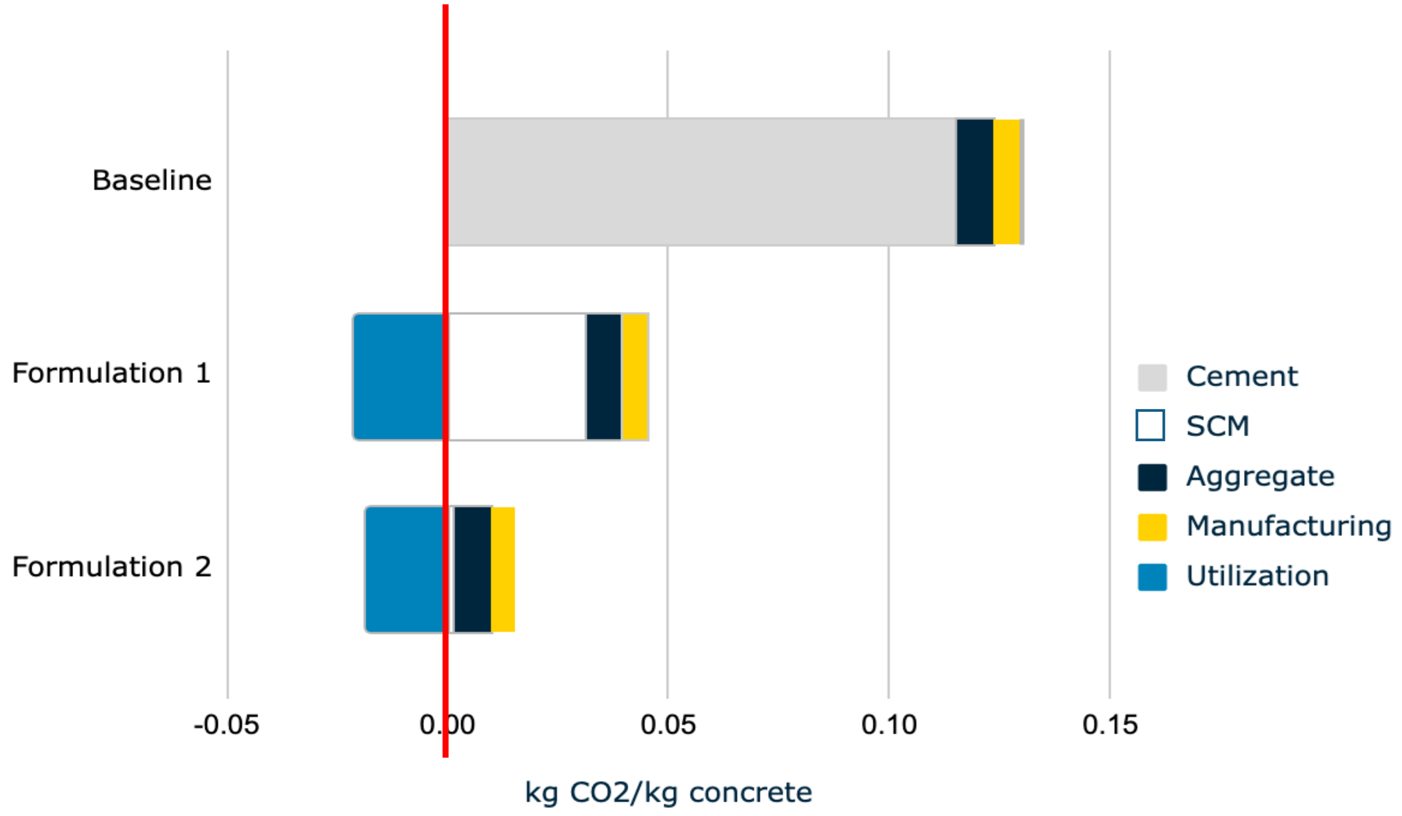
- CMUs manufactured with normal equipment
- Transferred to Carbonation Chamber co-located at generation site

Analysis indicates up to 0.75lb of CO2 captured per block.

Source: CarbonBuilt

Effect on Embodied Carbon

Plant 1, Line 1 – Projected Carbon Impact



Embodied CO_2 reduction	Carbon utilization (tpy)	Carbon avoidance (tpy)
82%	630	2,500
102%	550	3,400

Conclusion

- Technologies to reduce embodied carbon exist, and continue evolving
  - High optimization
  - Sequestration/ Mineralization
- Further industrialization is key, alongside co-location
  - Extend to precast concrete (wet cast)
- Incentives and policy changes can expedite adoption

MASTER®
BUILDERS
SOLUTIONS