ENGINEERING SOLUTIONS FOR SUSTAINABILITY:
MATERIALS AND RESOURCES 3

Toward a Circular Economy

February 18–19, 2017 | Denver, Colorado

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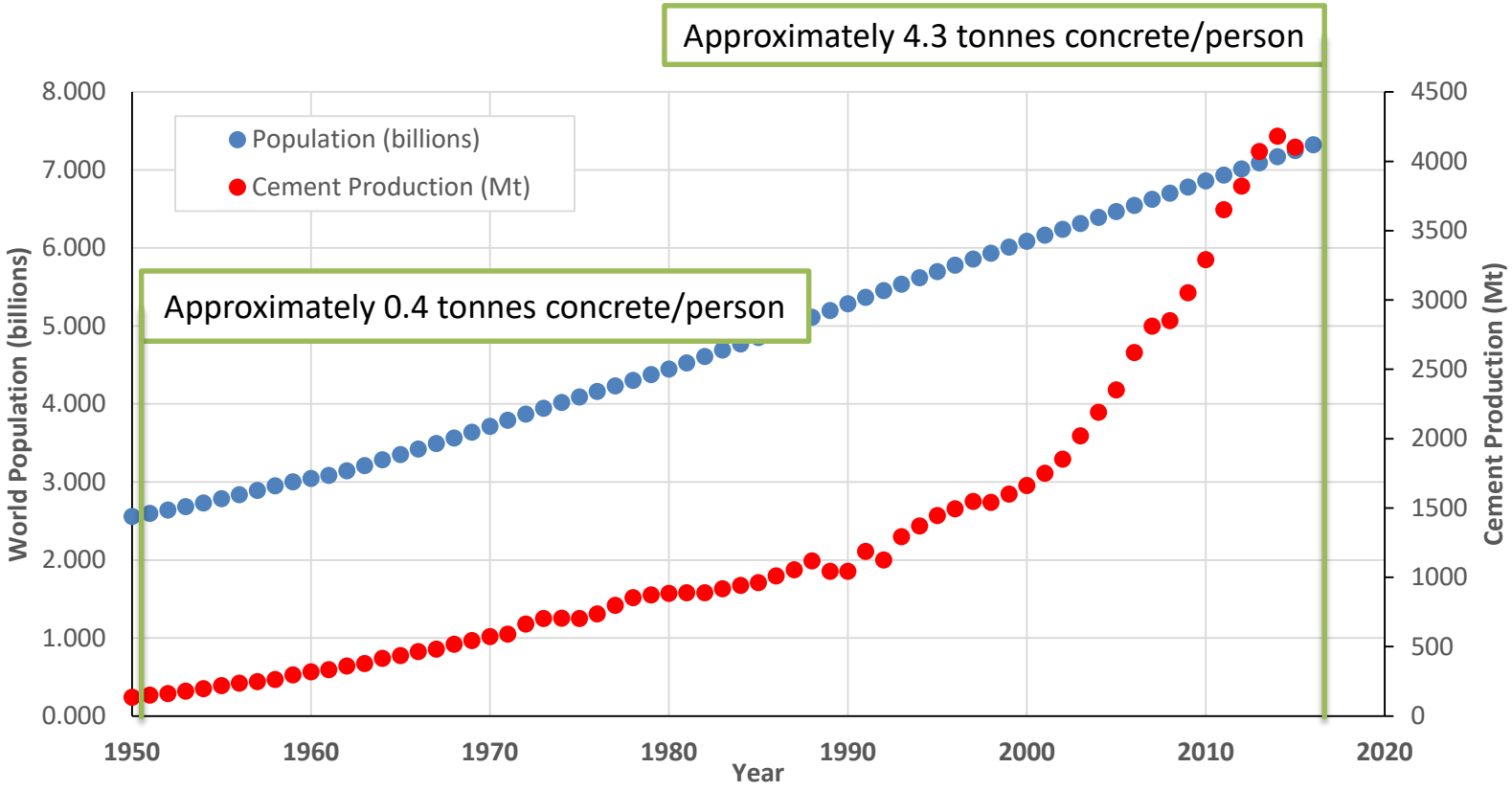
Session #8: Environment / Waste

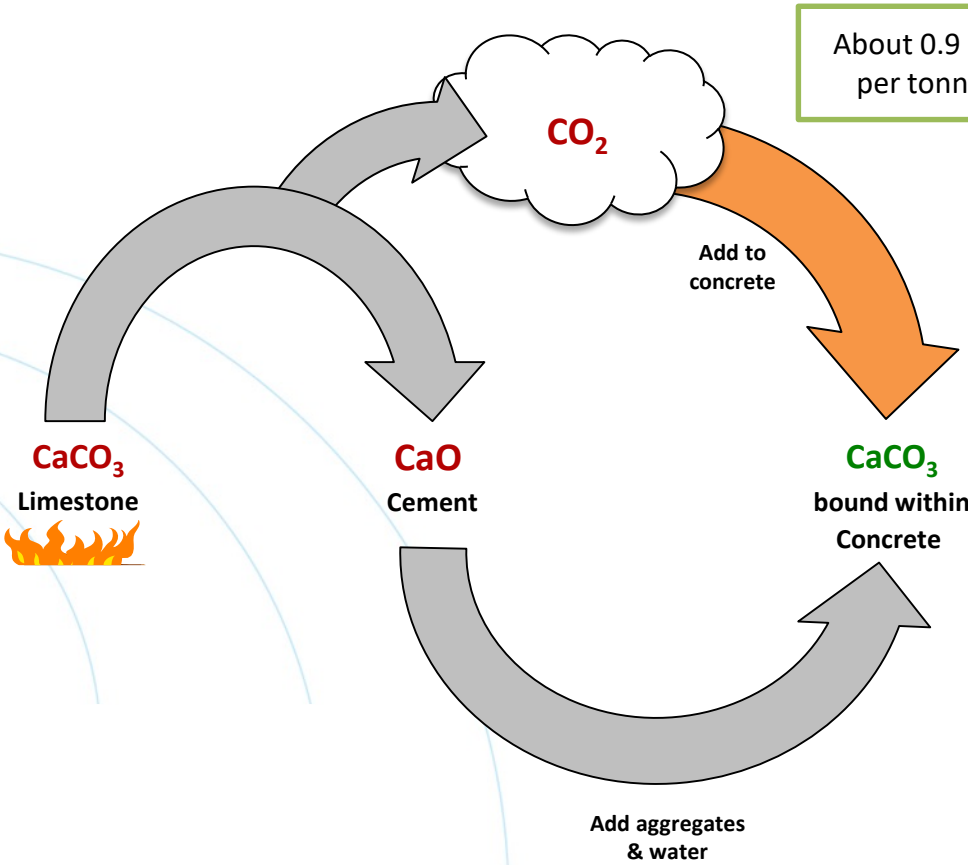
More Sustainable Concrete Using Waste Cement Industry CO_2

Sean Monkman, CarbonCure Technologies
Mark MacDonald, CarbonCure Technologies

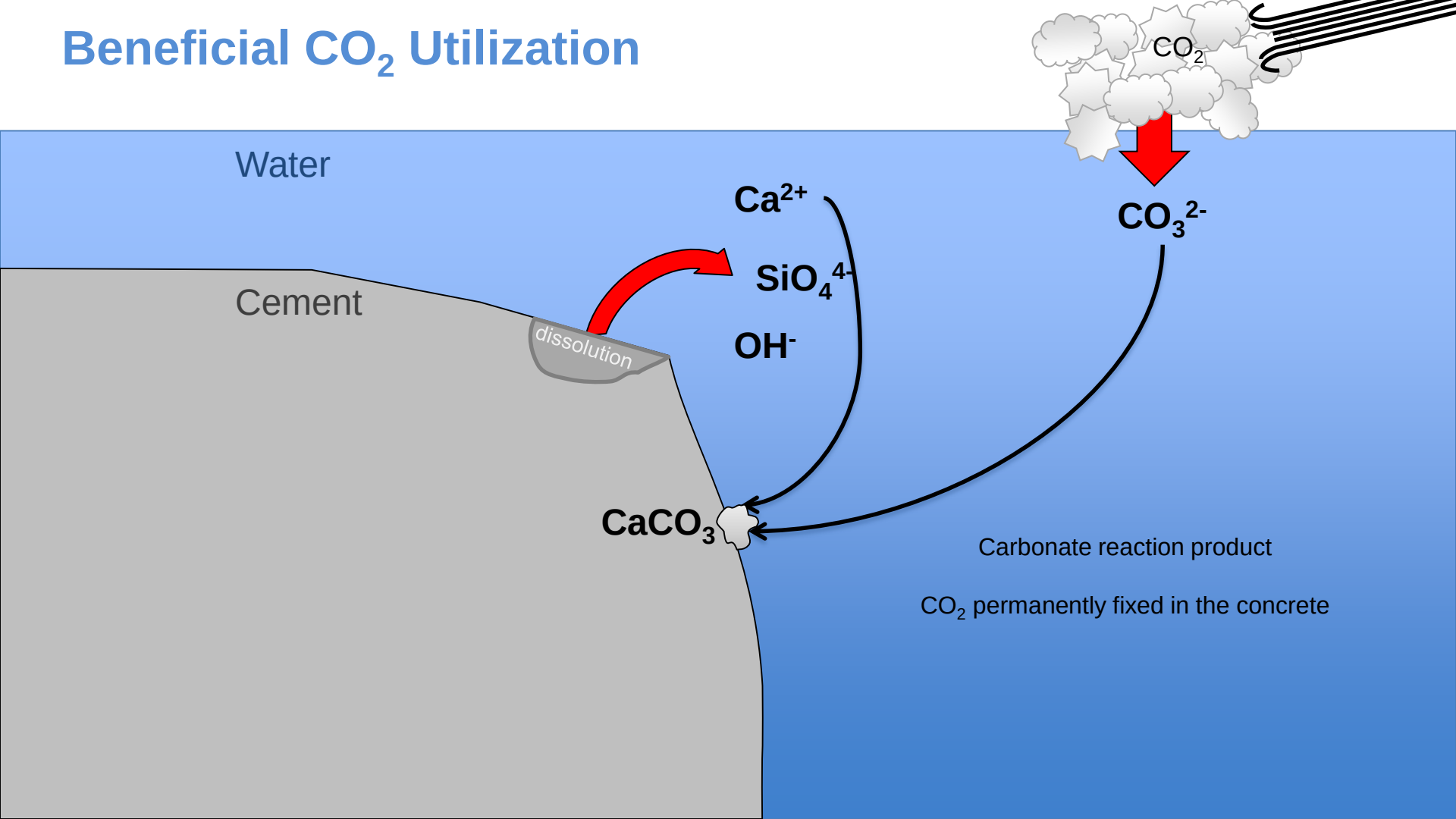
The importance of concrete



Circular Character of CO_2 Utilization in Concrete



Beneficial CO_2 Utilization



Three Methods of CO_2 Utilization in Concrete

Masonry Concrete

- 4 to 5 billion blocks produced annually in North America

Ready Mixed Concrete

- 70% of all cement, 60% of all concrete revenue
- 5,550 facilities in the US
- US production 336 million cubic yards in 2015

Concrete wash water

- Produced in washing of concrete trucks
- Creates water and sludge that requires disposal

1. Masonry implementation

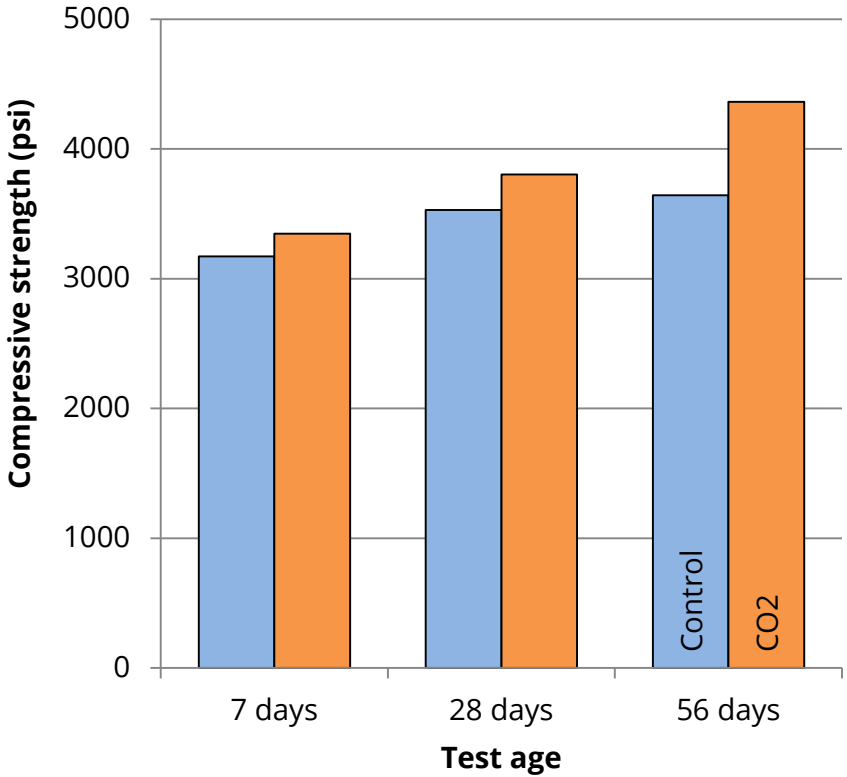
- Inject carbon dioxide into concrete mixer
- Maximum dose within mixing cycle
- Adjust water for appearance
- No change to cycle time
- CO_2 stored in concrete blocks
- Simple retrofit, same machines and same materials

Masonry implementation

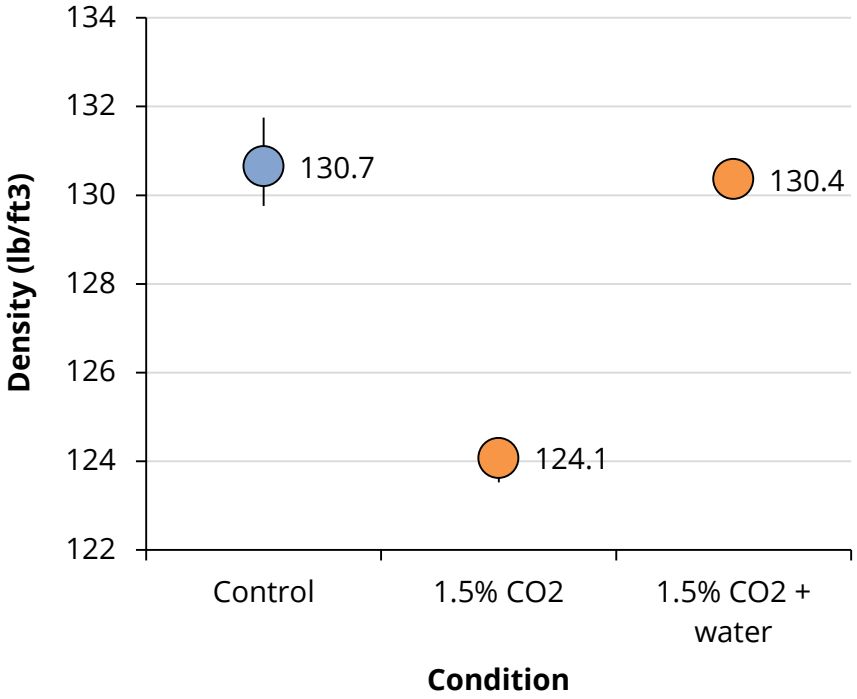
Strength benefit realized

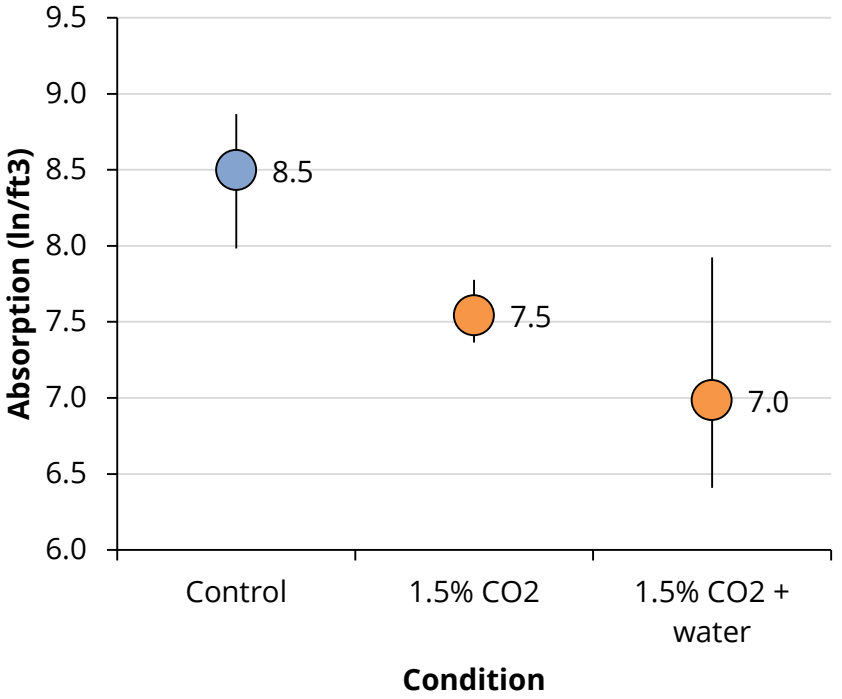
<u>Carbonated batch</u>

- Uptake was 1.40% by weight of cement
- Nominal mix water increase was 14%
- 7 day strength vs control: +6%
- 28 days: +8%
- 56 days: +20%



Masonry Properties



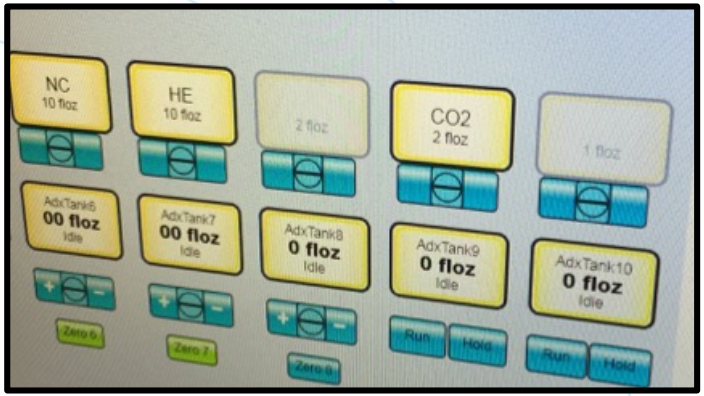


Carbonated: 5.0% lower density, 11% lower absorption
Carbonated w/ water increase: 0.2% lower density, 18% lower absorption

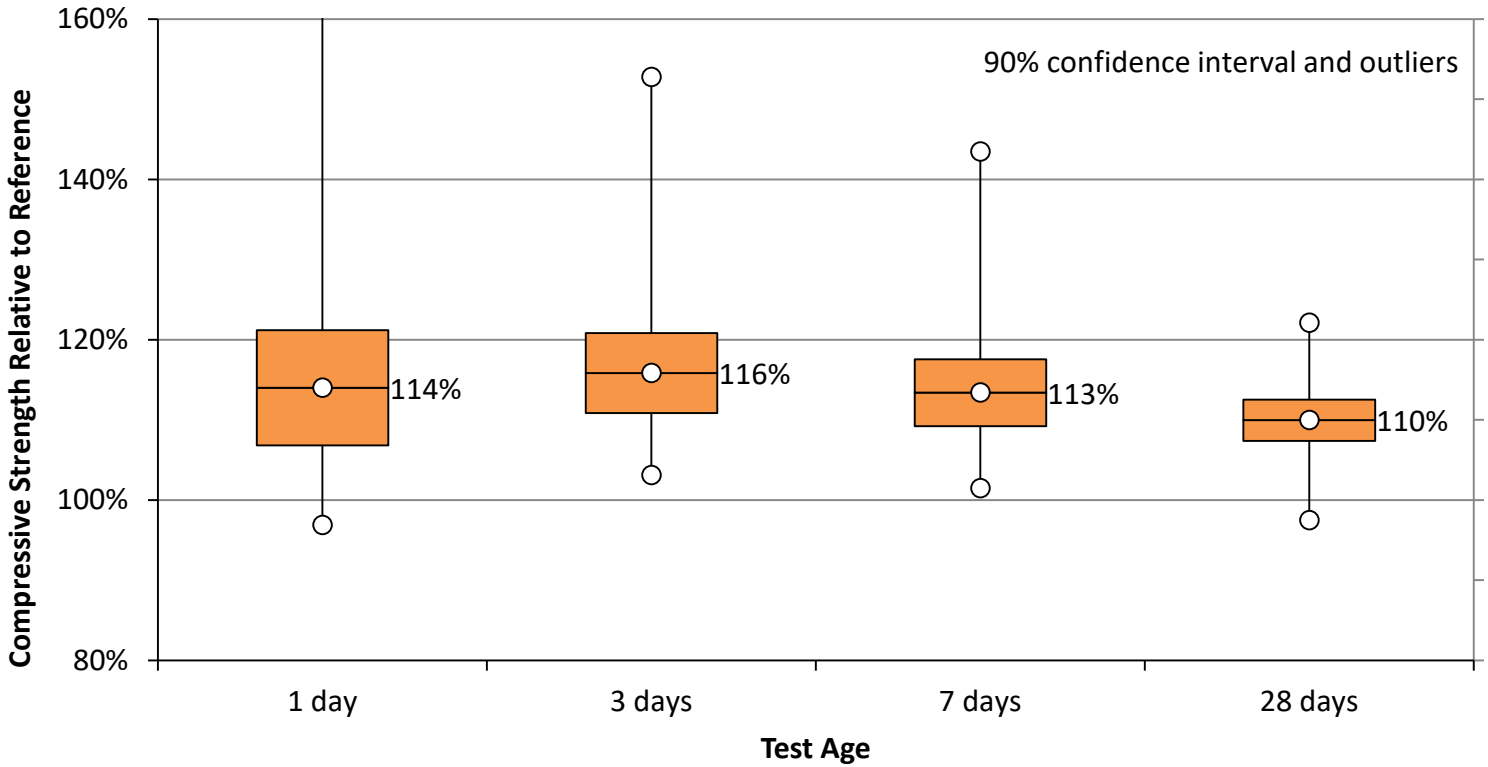
2. Ready mix implementation

- Inject carbon dioxide into concrete mixer
- Optimum dose during batching
- No change to cycle time
- CO_2 improves concrete properties
- Simple retrofit, same machines and same materials

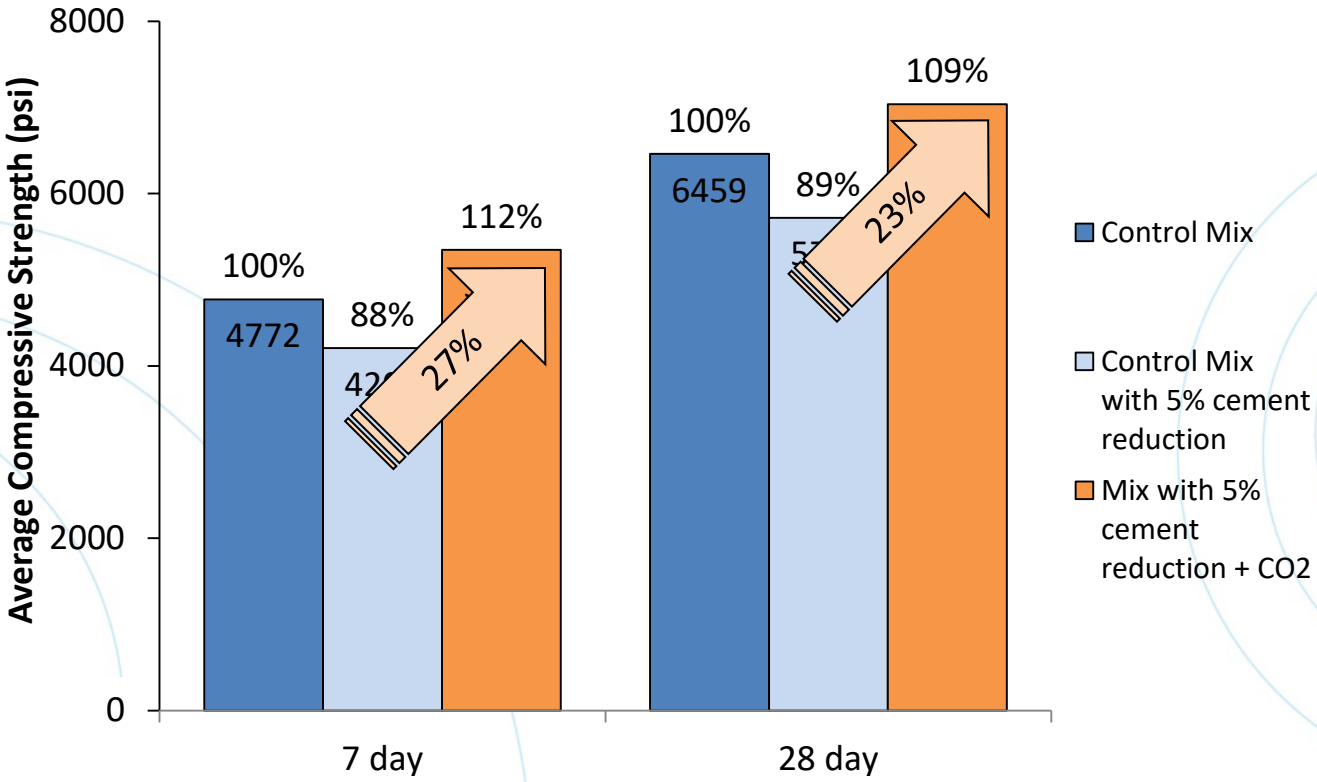
Ready mix implementation



Compressive Strength Results

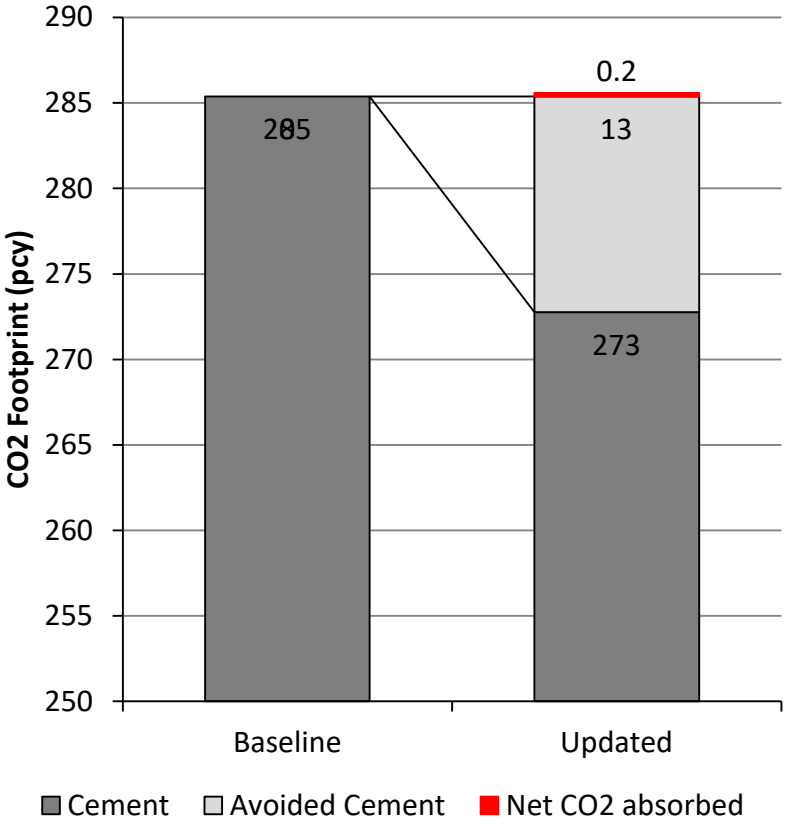


Ready mix results – three way comparison



Cement Reduction Case Study

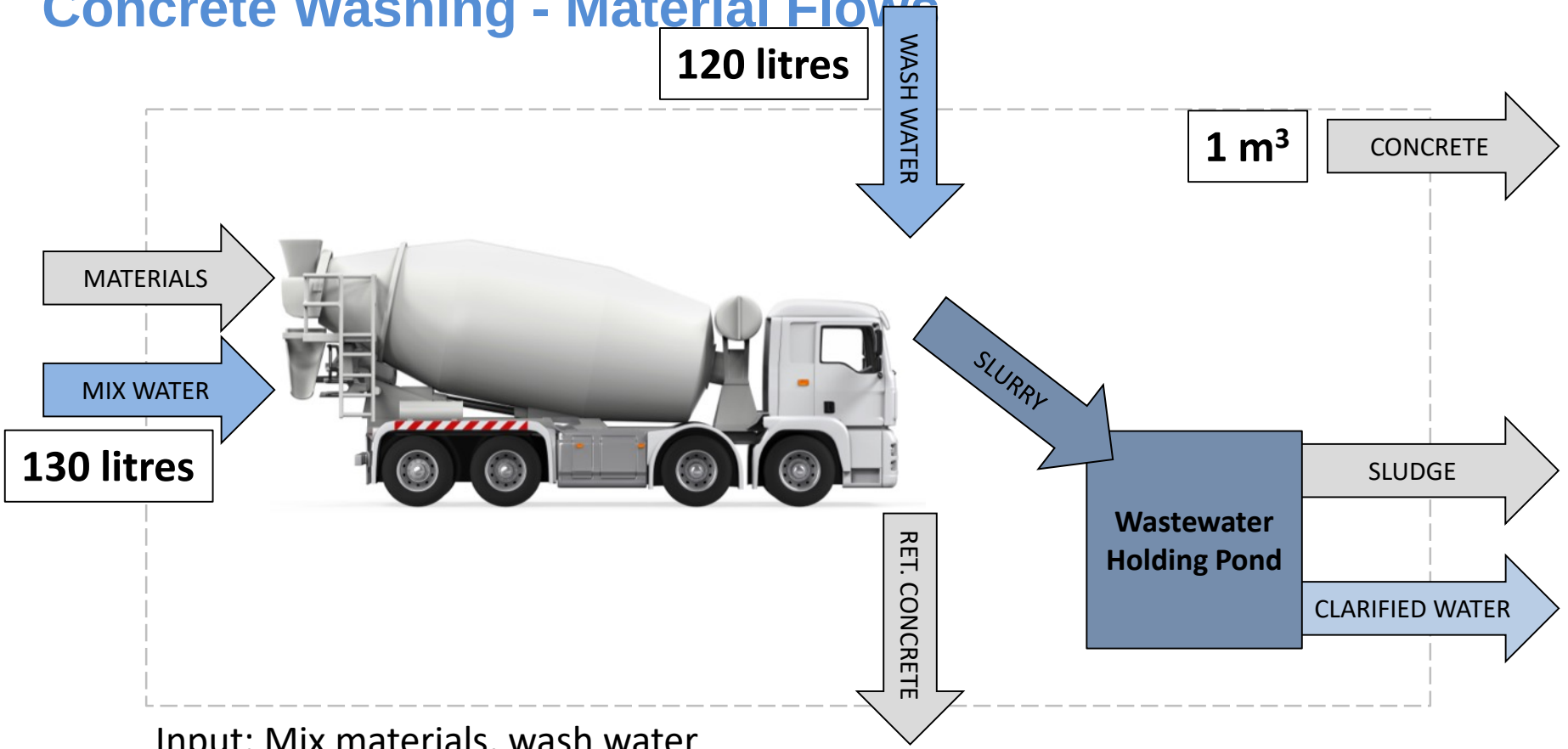
- Carbon footprint is reduced by 4.4%
- Cement reduction is responsible for 98.4% of the reduction
- CO_2 utilization served as a platform to make the reduction.
- Considering only the cement impact.



3. Wash water implementation

- Estimated annual discharge of 300 million gallons
- High pH water that needs to be treated before release
- Suspended cementitious solids settle out, removed and landfilled
- Reuse of the water in concrete negatively impacts workability and setting time.
- Age of water changes properties.

Concrete Washing - Material Flows



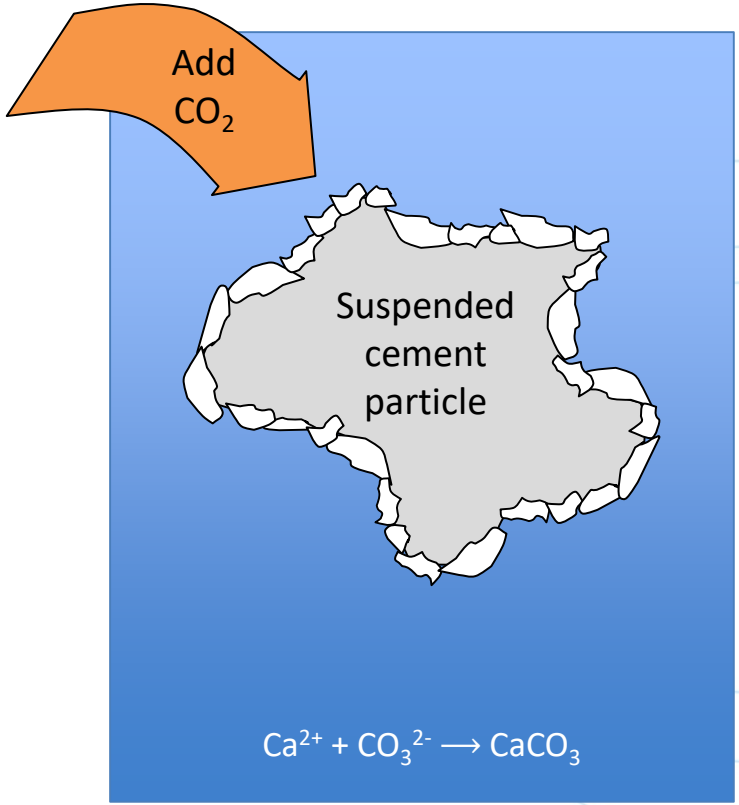
Input: Mix materials, wash water

Output: Concrete and process wastes

Source: NRMCA Member Industry-Wide EPD For Ready Mixed Concrete (2014)

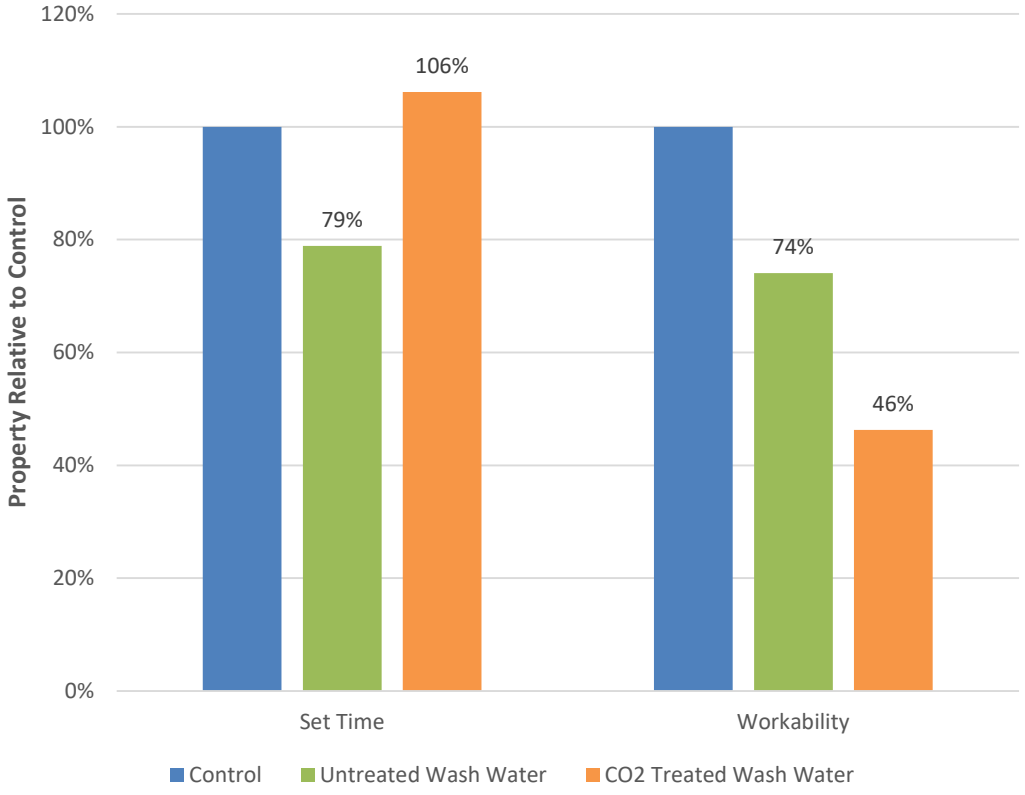
Wash water – CO_2 treatment

- Treat high solids wash water with CO_2
- CO_2 reacts with solids and is absorbed
- Reuse as concrete mix water
- Reduce solids disposal
- Reduce fresh water usage
- Recoup value of suspended solids



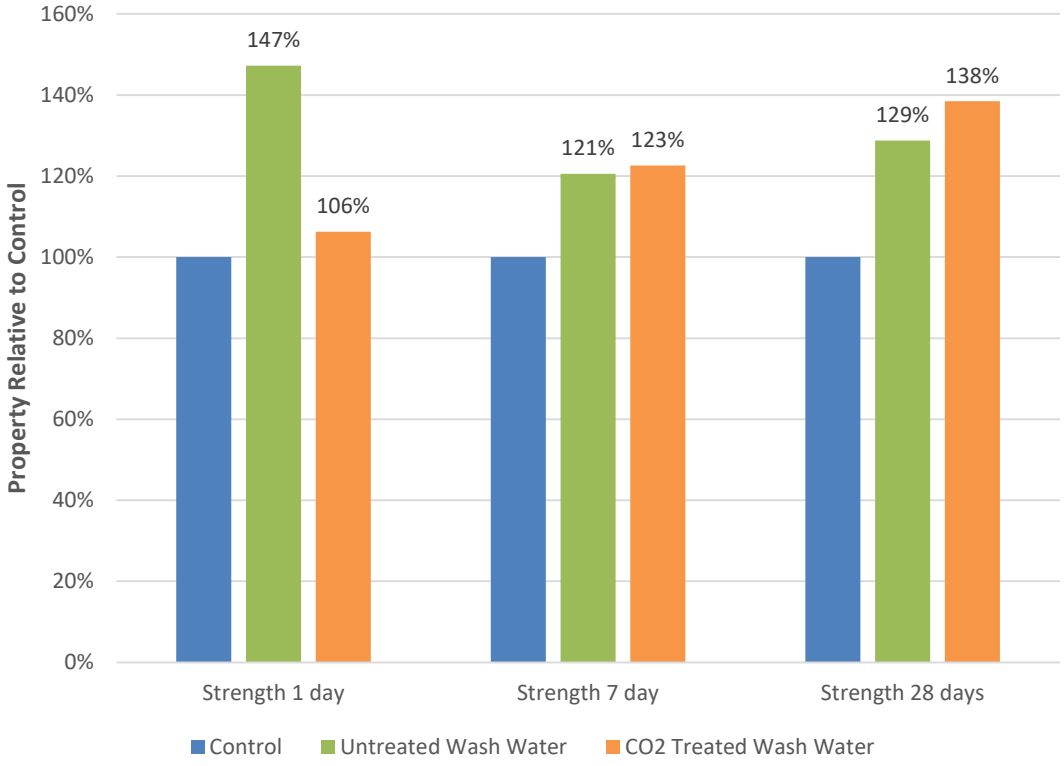
Wash water – fresh property results

- Set time and workability are barriers to reuse of wash water
- Mortar samples prepared with potable water, wash water and CO_2 treated wash water
- CO_2 reverses the set time issue
- Wash water concrete is stickier

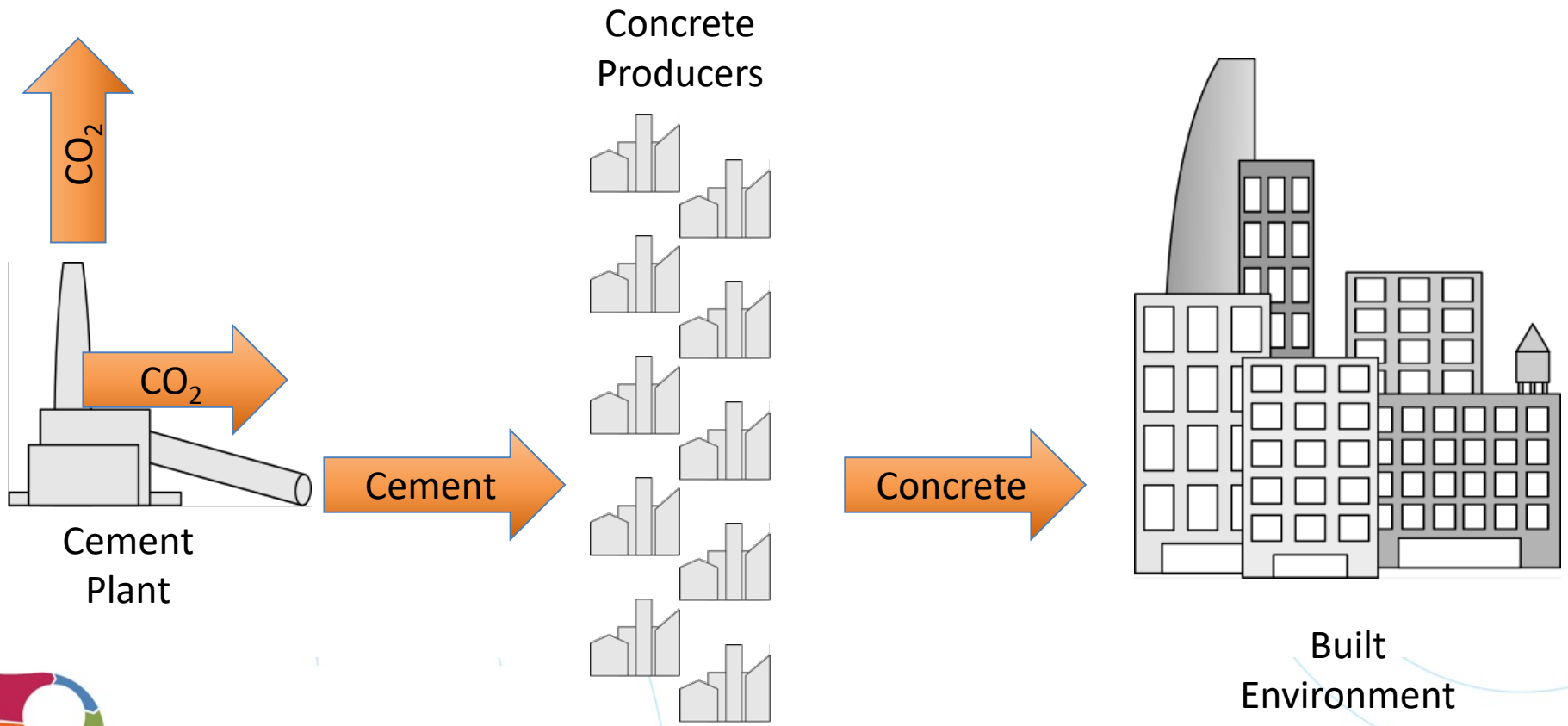


Wash water – compressive strength results

- Use of wash water resulted in improved compressive strength
- CO_2 treatment increased strength over untreated case
- Potential to remove cement, which would solve workability issue



Circular utilization of cement production waste



Looking Towards the Future

NRMCA 2011 SUSTAINABLE CONCRETE PLANT GUIDELINES

Performance Indicator	2020 Goal	2030 Goal
Embodied Energy	20% decrease	30% decrease
Carbon Footprint	20% decrease	30% decrease
Potable Water Use	10% decrease	20% decrease
Waste Created	30% decrease	50% decrease
Recycled Content	200% increase	400% increase

Relative to a baseline of 2007

CO_2 utilization can play a role in achieving improvements in carbon footprint, water usage, waste output and recycled content usage.

Thank You

Sean Monkman, PhD PEng

VP Technology Development

smonkman@carboncure.com

Twitter @carboncure