# Leveraging $CO_2$ as a strength enhancing admixture

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Americas Materials

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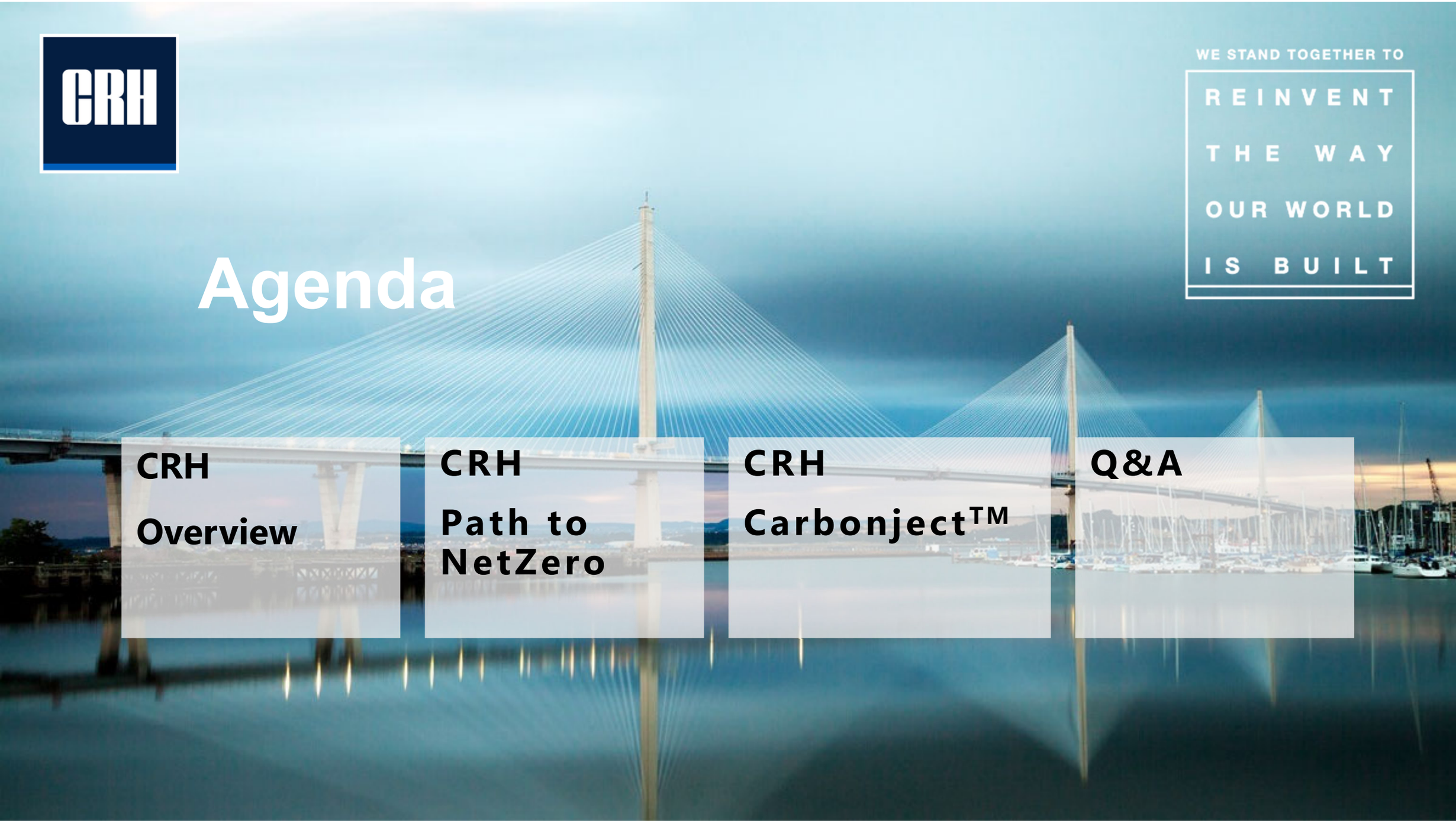
Dufferin Concrete

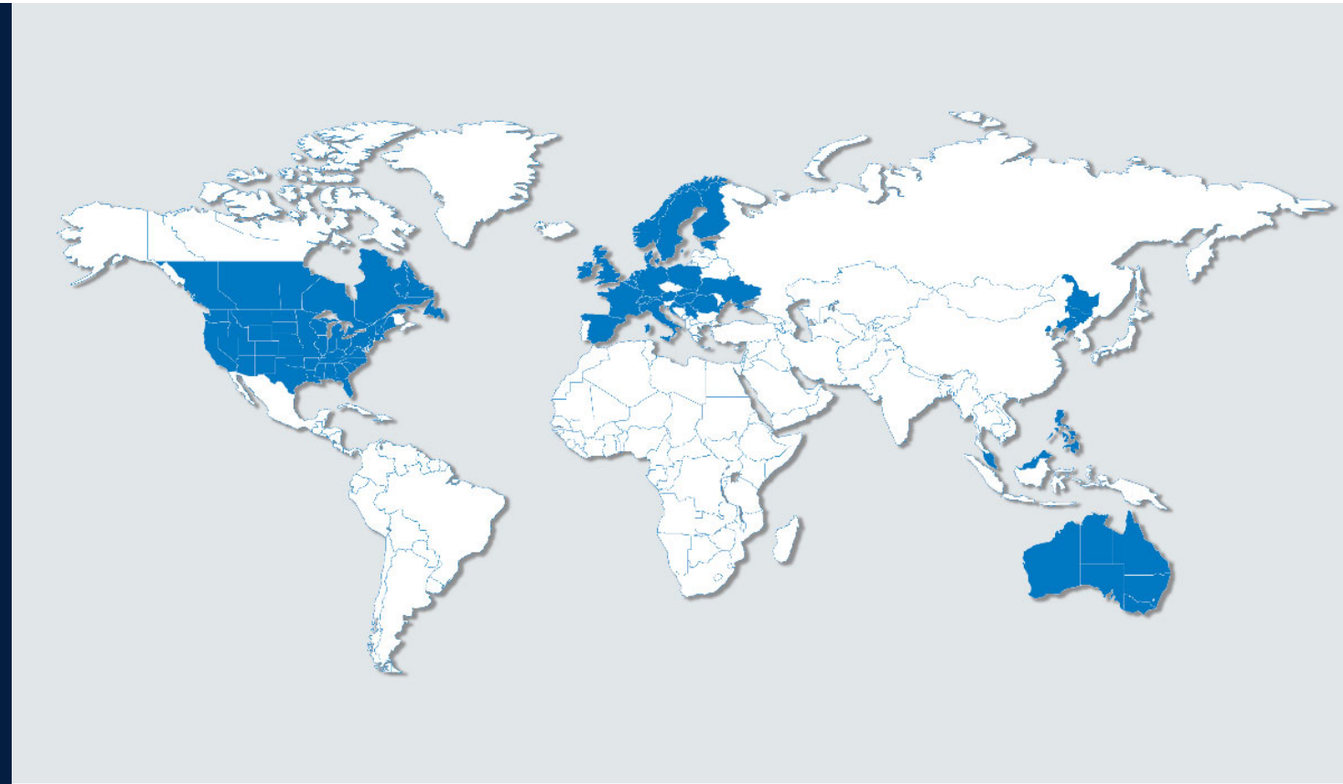



# Agenda

- CRH Overview
- CRH Path to NetZero
- CRH Carbonject™
- Q&A

# CRH at a glance

CRH is the leading building materials solutions business in the world (1)



| 35.6 | 80,000 | 28 | #1 | 200+ |
|---|---|---|---|---|
| $ bn revenue 2024 | Colleagues | Countries | Building materials N. America & Europe | Operating companies |

* https://www.crh.com/ - About Us, CRH Annual Report

# Transforming Essential Materials into Value-Added Solutions

**Sub-Surface Solutions**


**At-Grade Solutions**

**Building Solutions**

**Finishing Solutions**

**Essential Materials**

**Aggregates**

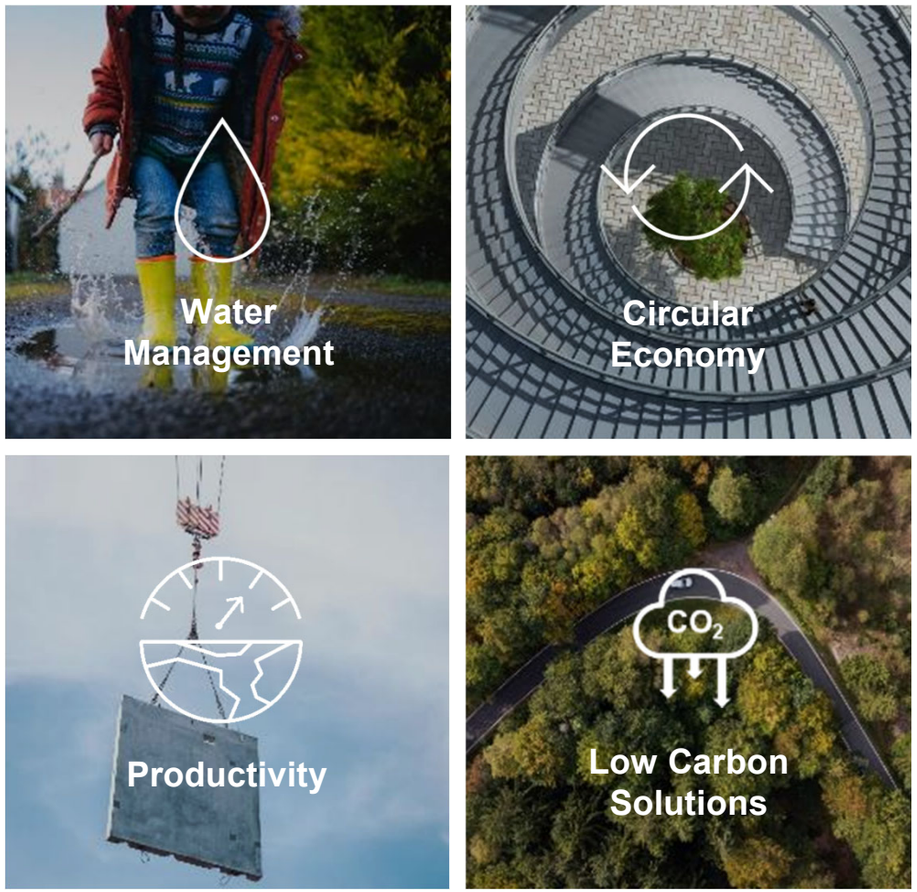
**Cement**

# Market leading brands across the built environment ...

Sub-surface › At Grade Level › Building › Finishing

# With CRH leading in sustainable construction …

## *Key Innovation Focus Areas*




**#1** Largest recycler in North America

**>100** Research projects ongoing

**$250m** Venturing & Innovation Fund launched in 2022

**~70%** of Sales are 100% recyclable

MSCI ESG RATINGS AAA · Member of Dow Jones Sustainability Indices · SCIENCE BASED TARGETS · CDP · SUSTAINABLE DEVELOPMENT GOALS · TCFD



* https://www.crh.com/ - Annual Report - Our Business

# taking the lead on decarbonization ... our ESG Commitments


**WASTE**
Reimagining how materials are used to drive circularity

- Recycle and reuse construction and other waste
- Enable resilient, resource efficient buildings and infrastructure
- Build more circular supply chains

**DECARBONIZATION**
Innovating for a low-carbon future

- Design-out embodied and operational carbon
- Use carbon we can't avoid
- Support the deployment of infrastructure for the energy transition
- Develop energy efficiency solutions for buildings and infrastructure

**WATER**
Advancing solutions to solve global water challenges

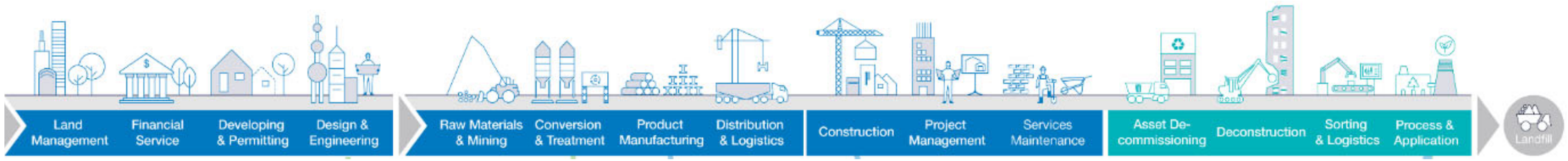
- Conserve water across the value chain
- Upgrade water infrastructure and ground water recharging
- Advance solutions that enhance resilience to flooding

* https://www.crh.com/ - Our Sustainability Framework

# Innovating and venturing across the value chain

iCSC Innovation Centre for Sustainable Construction
A CRH COMPANY

AI OPTIMISATION | CONSTRUCTION DESIGN SOLUTIONS | WASTE-2-VALUE | BINDERS OF THE FUTURE | LOW CARBON BINDERS | CHEMICAL ENHANCED SOLUTIONS | SENSORS & IOT | WATER INFRA SOLUTIONS | INDUSTRIALISED CONSTRUCTION | LOGISTICS / PROCUREMENT SOLUTIONS | ROADS OF THE FUTURE | WATER TECHNOLOGY




CRH VENTURES

**LOW CARBON BINDERS**
- Sublime Systems (CO2)
- carbon upcycling

**MIX OPTIMIZATION**
- AICRETE
- CARBONject™ (CO2)

**$CO_2$ MINERALIZATION**
- CarbiCrete (CO2)

**SENSORS & DATA FOR MIX OPTIMIZATION**
- converge

**WATER LEAK DETECTION & MONITORING**
- FIDO

Circularity | Productivity | Decarbonisation | Water

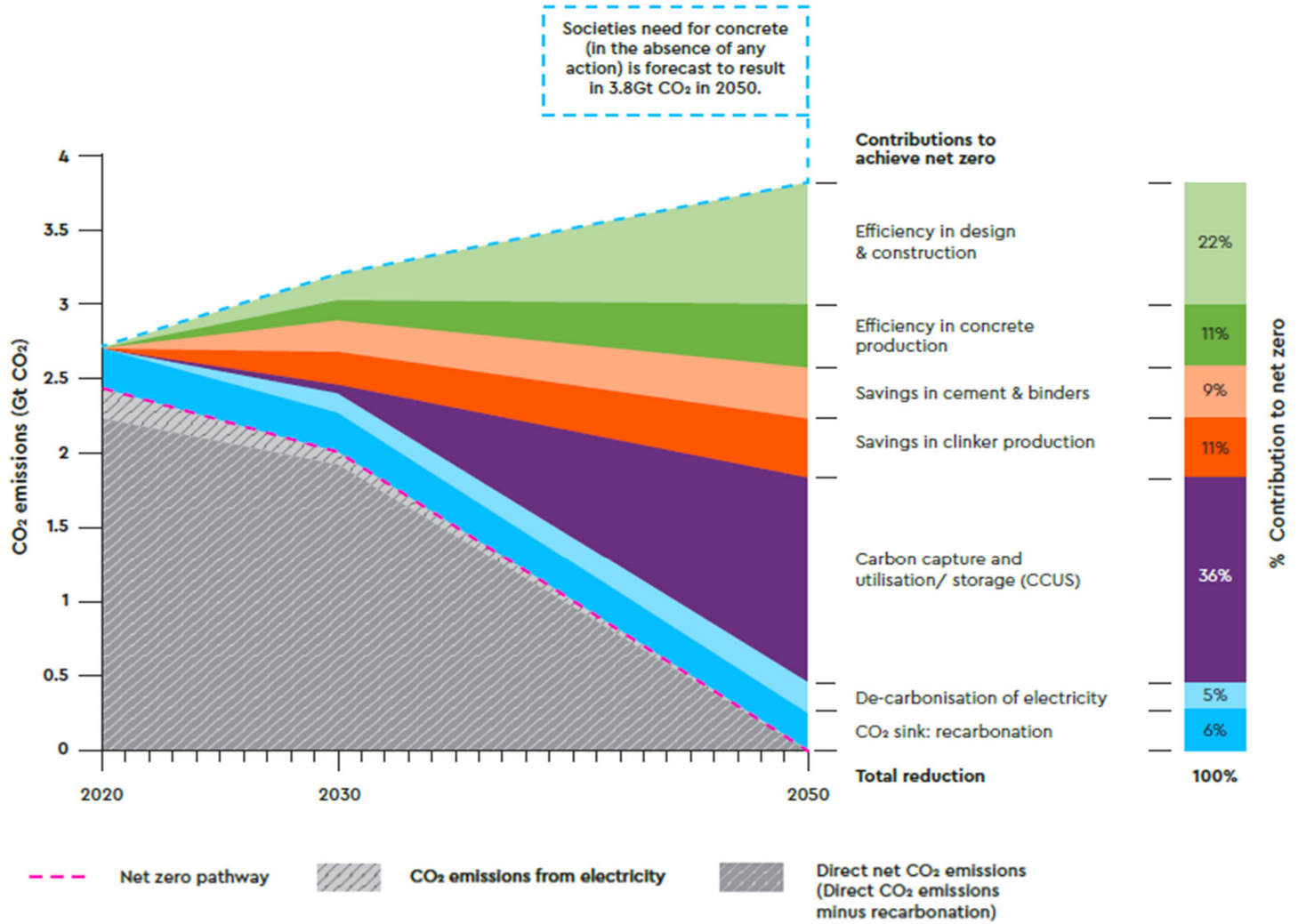


* crhventures.com/portfolio

# Sustainable Construction

*Low-Carbon Concrete Materials*

# GCCA … Net Zero transition pathway




**Areas of Potential collaboration**

- Design and construction choices available
- Collaborate to drive schedule and productivity benefits alongside $CO_2$ savings

- Increasing quality management and material science application available. Significant digitalisation transformation underway.
- Increasing availability of 'Clinker' replacements. Capability to adopt linked to design and specification.

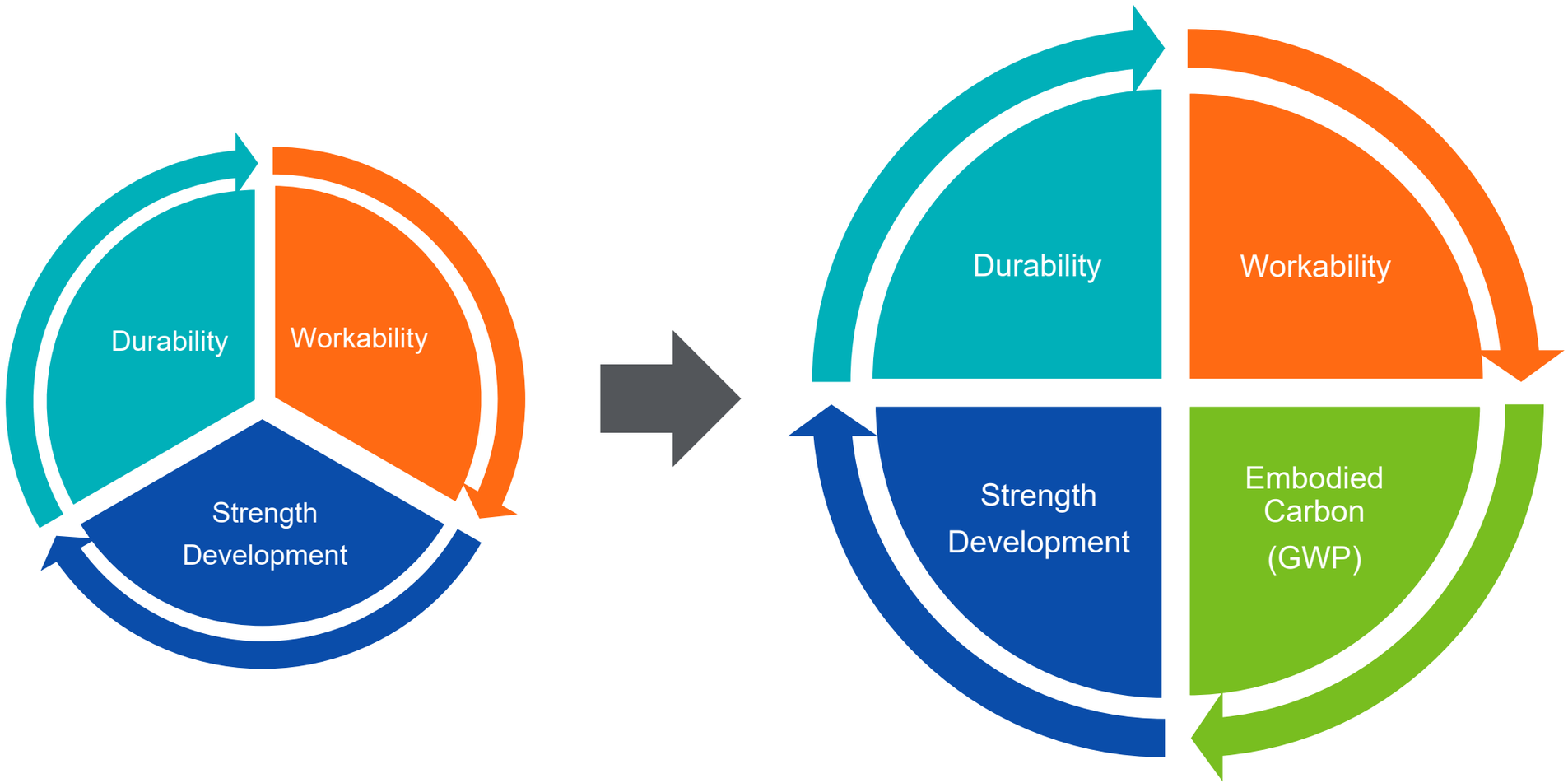
- Post 2030 impact anticipated in limited locations.

- Energy Transition underway – Increase recognition of $CO_2$ reduction accelerates transition.



* https://gccassociation.org/concretefuture/our-path-to-net-zero/

# The changing demands on concrete

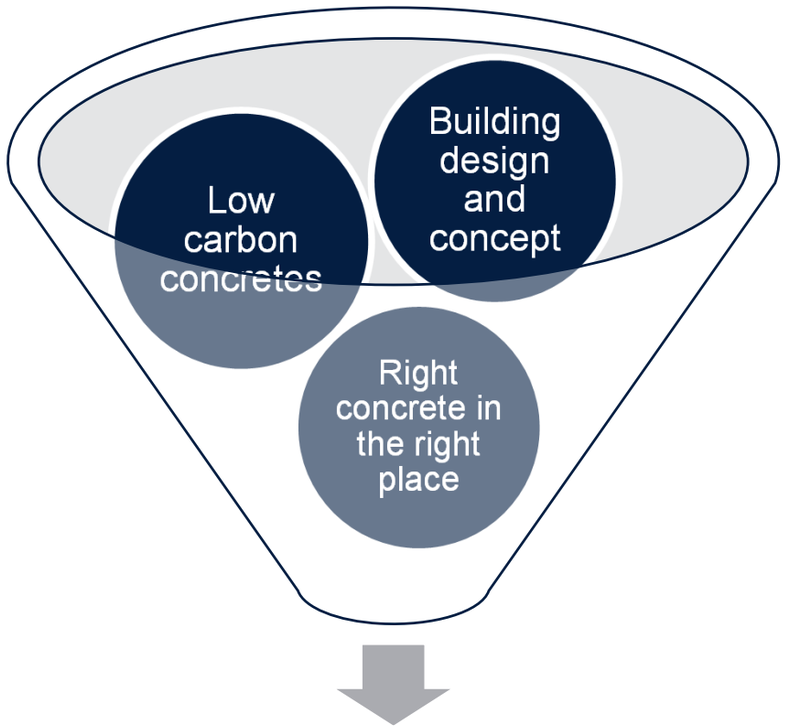


# Developing a low-carbon concrete solution

*Early involvement and a collaborative approach*

**Concrete Producer**

- Low carbon binders
- Admixtures to enhance performance
- Mix design optimisation
- Recycled materials utilisation
- Production efficiency
- Sustainable transport




**Optimised $CO_2$ solution**

**Client, specifier and contractor**

- Optimised construction method
- Right performance in the right place
- Optimal concrete strength development
- Thin element building design (Less concrete, Higher strength)

# CARBONject™

# Genesis of an Innovation

United Nations | Climate Action

13 CLIMATE ACTION

+

Mineralization equation:

$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$

+

A $CO_2$ pH water treatment system clogged with $CaCO_3$

=

# Carbon Sequestering

## What can be achieved

The sequestering equation provides 2 benefits:

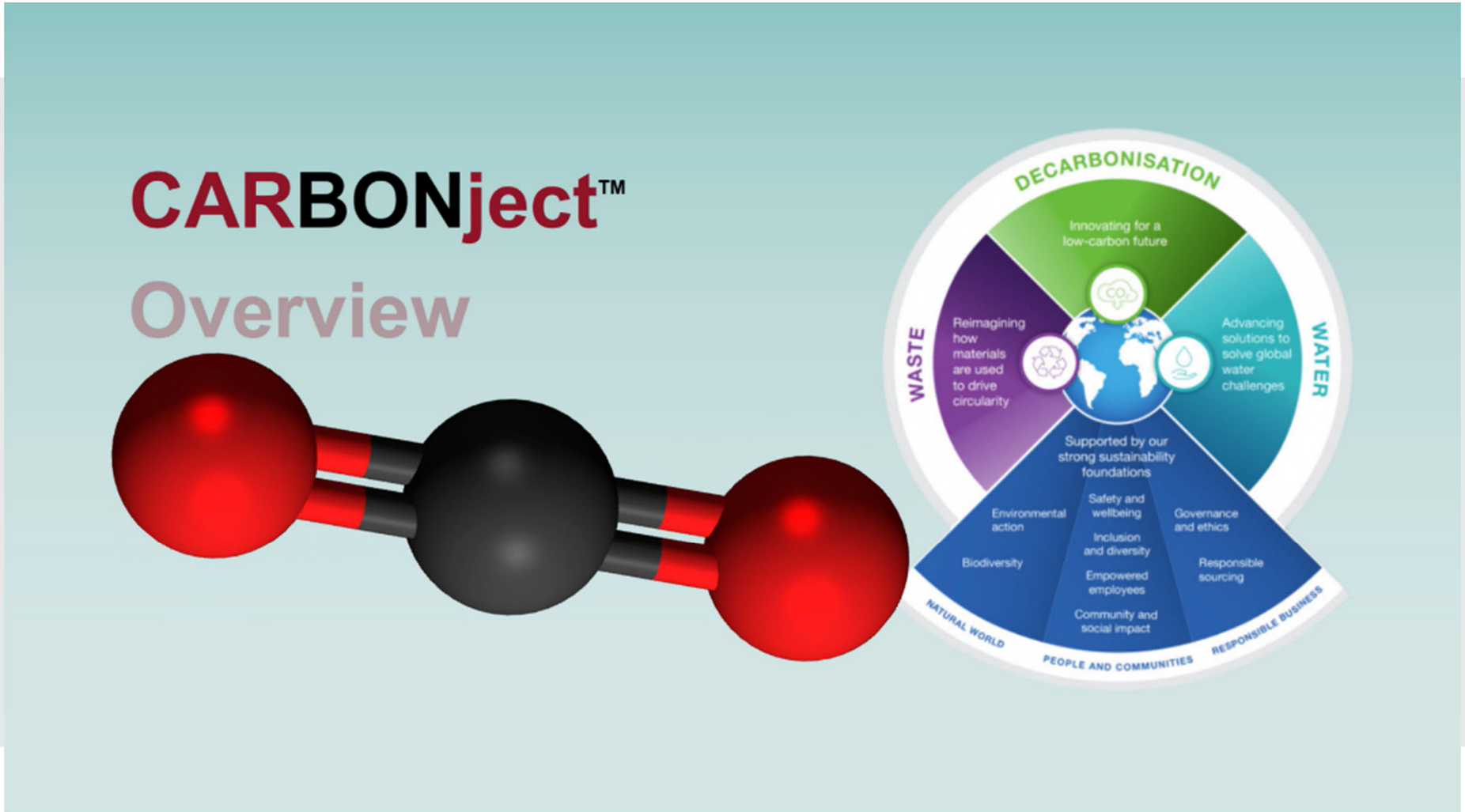
1. The resulting $CaCO_3$ produced acts as a strength enhancer allowing the concrete producer to the reduce cement requirements resulting in a lower carbon footprint.
2. The injected $CO_2$ is locked in the concrete.

At the present stage, the process can reliably create enough $CaCO_3$ to gain 1.5MPa.

The 1.5MPa gain translates into a cementitious reduction of 15 $kg/m^3$

This is approximately a10kg $CO_2/m^3$ reduction of the Concrete Carbon footprint

# CARBONject™ Overview




Dufferin
A CRH COMPANY

# Turning an Idea into a reliable process

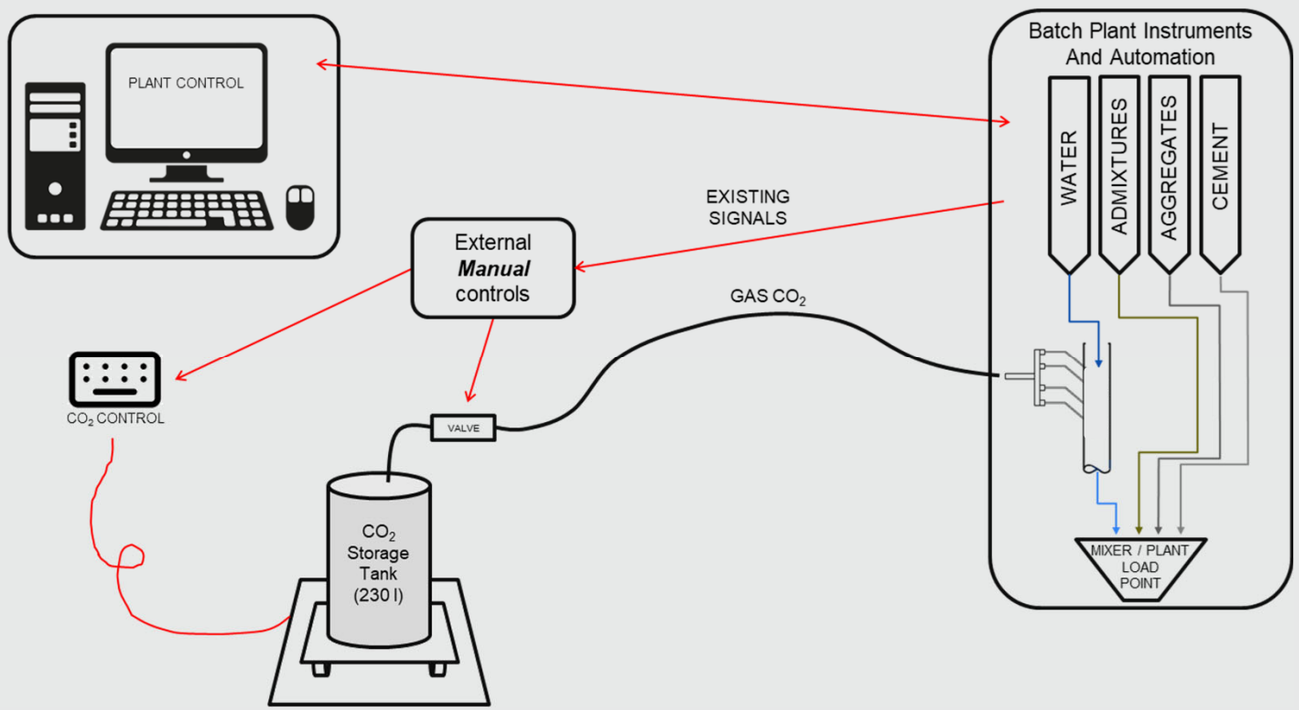
**Defining Success Criteria:**

- Must convert a high percentage of $CO_2$ (>60%) and create a **measurable** increase in $CaCO_3$
- Can not slow down **production**
- Must be **repeatable** with little variation throughout the entire concrete batch
- Needs to be applicable to premix plants and drybatch plants

**R&D Process Evolution:**

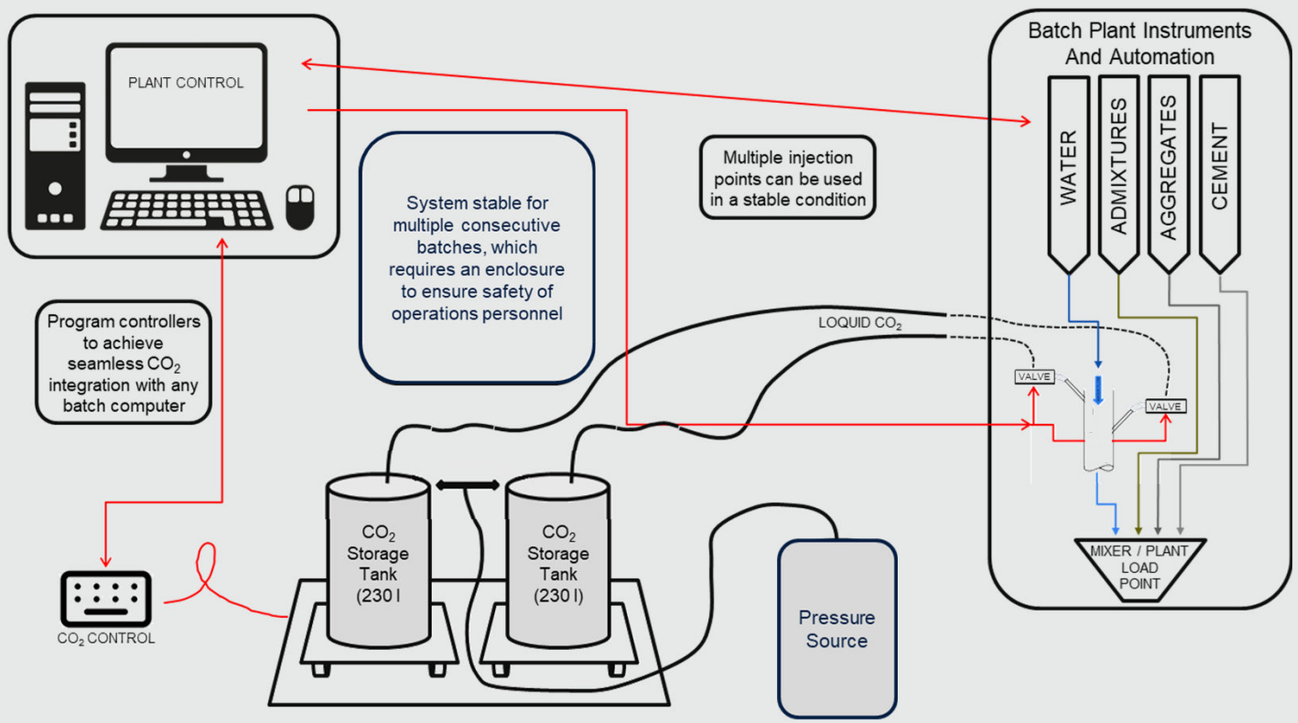
- First generation: $CO_2$ in gas form, little mineralization, 100% manual process, complex model difficult to automate and replicate, only dry-batch RMX facilities.
- Last generation: $CO_2$ in liquid form, much higher mineralization (85%), fully automatic process, completely replicable and suitable for any kind of RMX production plant.

# Step by Step Process Evolution: Feedback loop to guarantee safety and process control



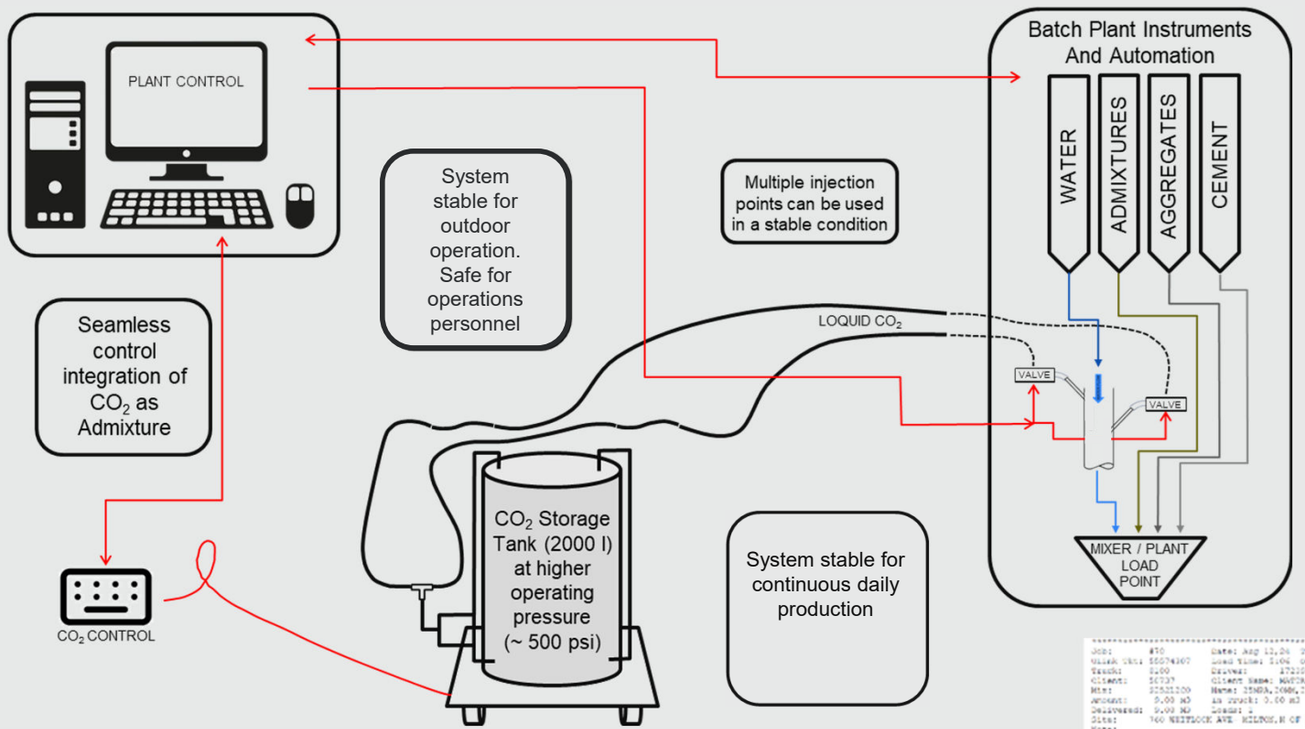

Starting with a gas injection system, manual, difficult to replicate, impractical to implement, with low mineralization

# Step by Step Process Evolution: Feedback loop to guarantee safety and process control

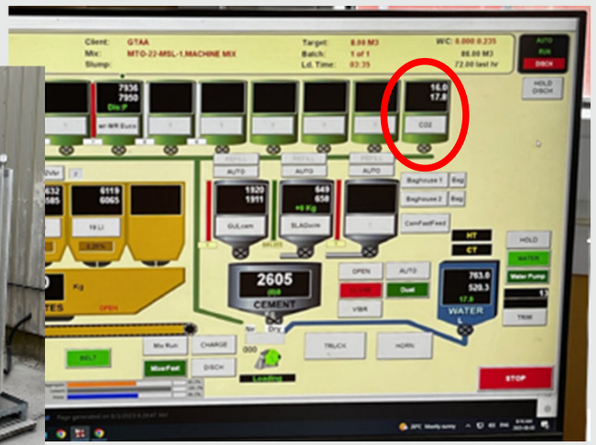


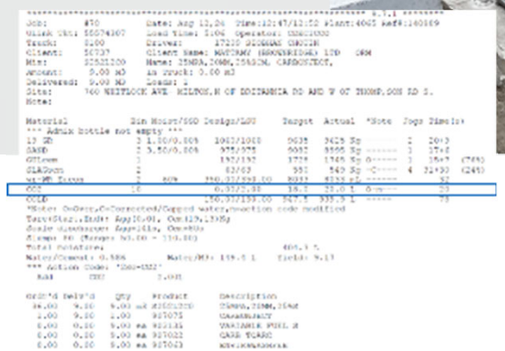

Evolving to a liquid $CO_2$ system, able to manage higher volume, semi-automated,


# Step by Step Process Evolution: Feedback loop to guarantee safety and process control



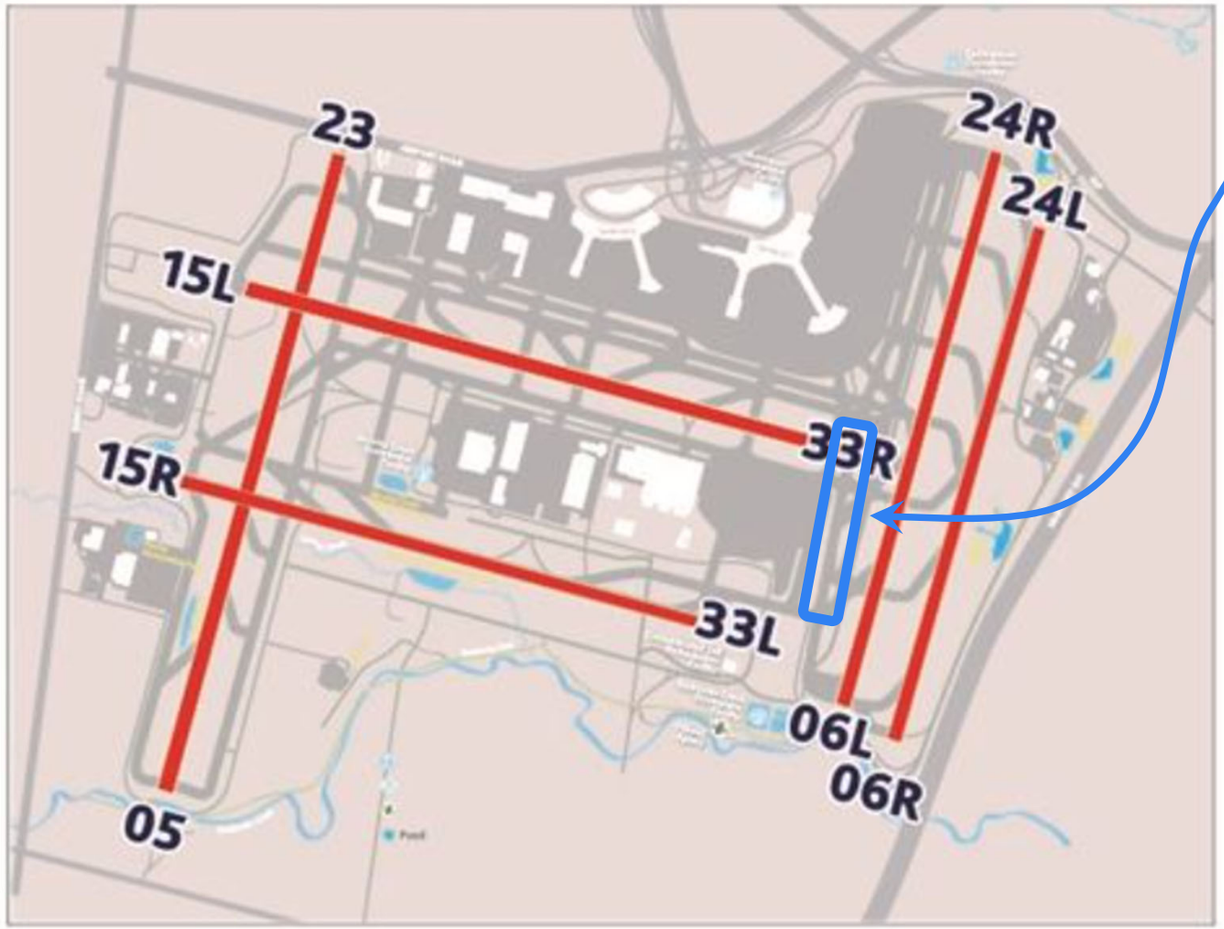

And now into a fully automated, large volume system, that allows us to setup injection rates to project-specific needs



# Project Highlight #1

## YYZ




Project Scope: Taxiway D Rehab, 2023

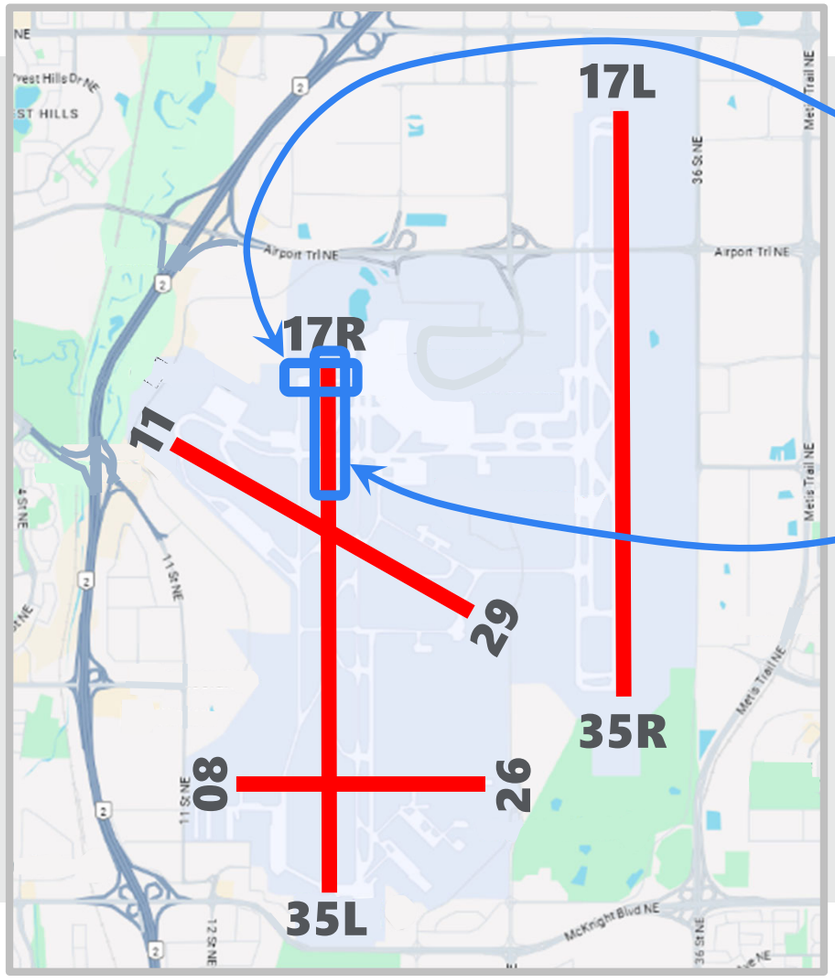
Volume of Concrete used: ~5600 $m^3$ of machine-placed concrete, ~300$m^3$ of hand-placed concrete

Production and Delivery: Premix plant, about 4.5km away from mid-point of project, delivered in dump trucks

Exposed Concrete

# Project Highlight #2

## YYC




Project Scope: Runway 17R35L Rehab, Taxiway A Rehab, 2024

Taxiway: Volume of Concrete used: ~3900 $m^3$ of machine-placed concrete, ~1300$m^3$ of hand-placed concrete

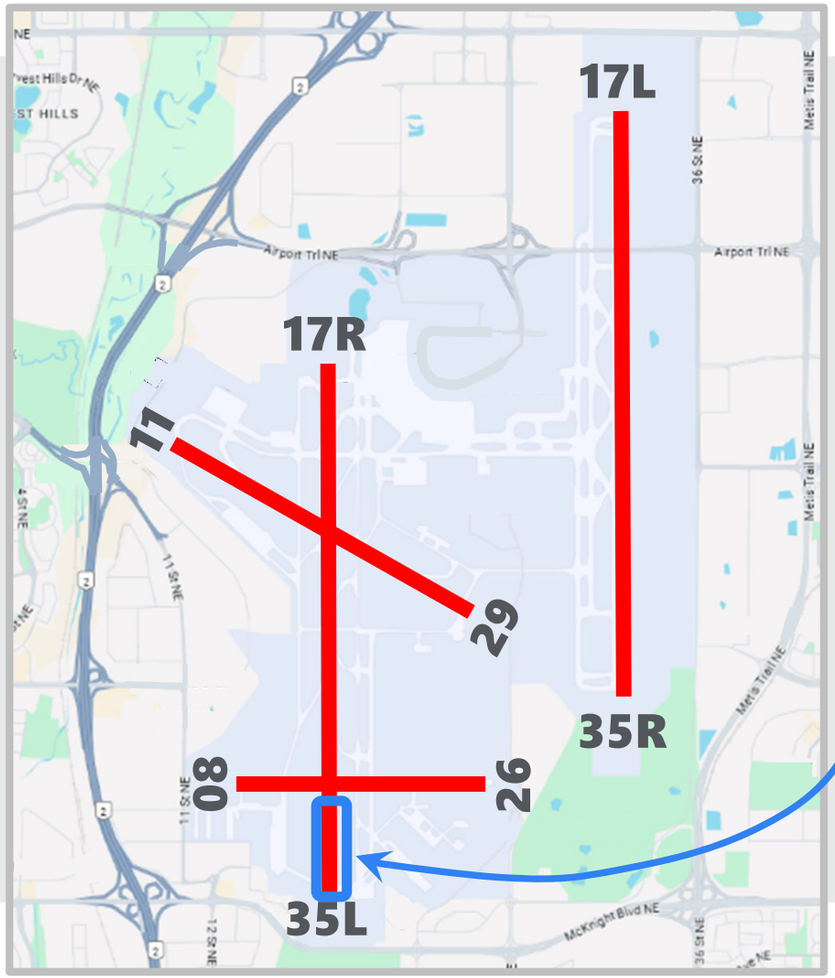
Runway: Volume of Concrete used: ~5100 $m^3$ of machine-placed concrete, ~100$m^3$ of hand-placed concrete

Production and Delivery: Premix plant, about 10 km away from entry point of project, about 20-25 min, delivered in dump trucks

Exposed concrete

# Project Highlight #3

## YYC




Project Scope: Runway 17R35L Rehab, 2025

Taxiway: Volume of Concrete used: ~5100 $m^3$ of machine-placed concrete, ~400$m^3$ of hand-placed concrete

Production and Delivery: Premix plant, about 4 km away from access point of project, delivered in dump trucks

Exposed concrete

# Highlights of Results Achieved
## YYZ

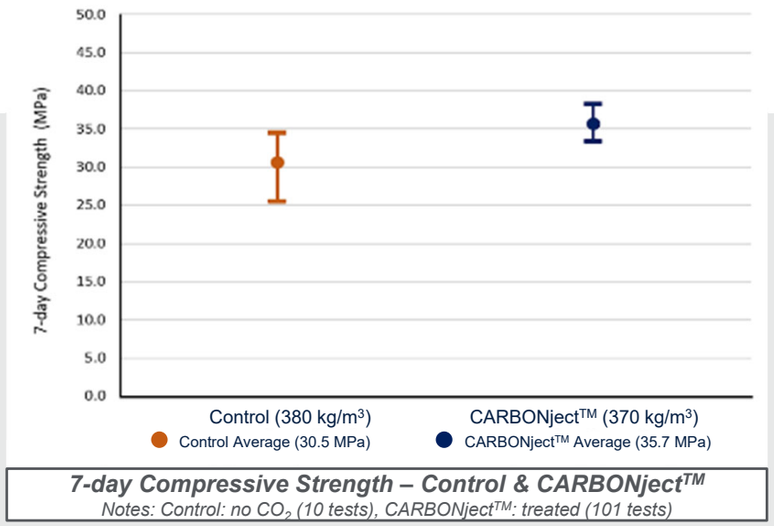
- Total 31% (Ashgrove Mississauga cement EPD) and 41% (GTAA cement benchmark) $CO_2$ reduction
- Average cement reduction of 15.2 kg/m$^3$ (25.6 lb/yd$^3$)
- Increase of 8% in compressive strength observed for CARBONject™ mixes:
- Slightly higher flexural and splitting tensile strengths compared to all reference mixes
- Performed sound durability (AVS, salt scaling, freeze and thaw, etc.)
- 85% conversion rate of carbon dioxide to calcium carbonate based on Thermogravimetric Analysis (TGA) testing conducted at Ash Grove Technical Center @ Kansas City, USA

# Highlights of Results Achieved
## YYC

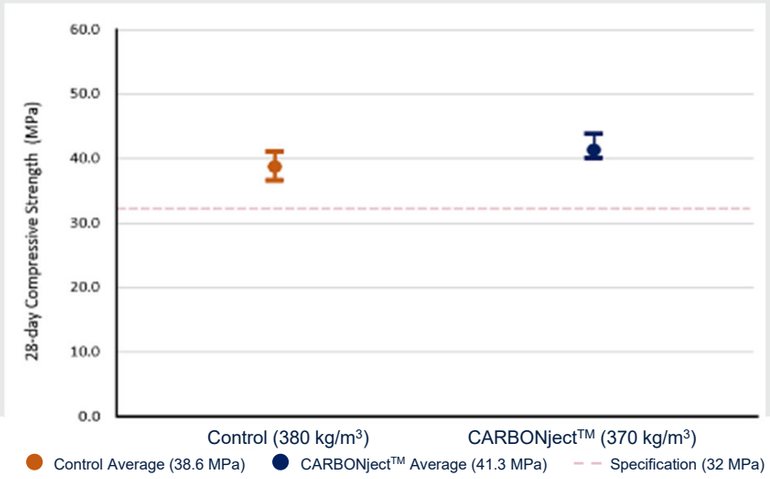
- Combined the use of $CO_2$ injection with the use of reclaimed fly ash, crushed local gravel and low alkaline cement, successfully accomplishing the required reduction of 75 tons of $CO_2$ per 10,000 $m^3$ of concrete
- Average cement reduction of 10 $kg/m^3$ (16.8 $lb/yd^3$)
- Increase of 7% in compressive strength observed for CARBONject™ mixes:
- 10% higher flexural strengths compared to all reference mixes
- Excellent AVS results
- Plastic performance results remained similar

# Comparative Mix Behaviour – Case Study Results

COMPRESSIVE STRENGTH

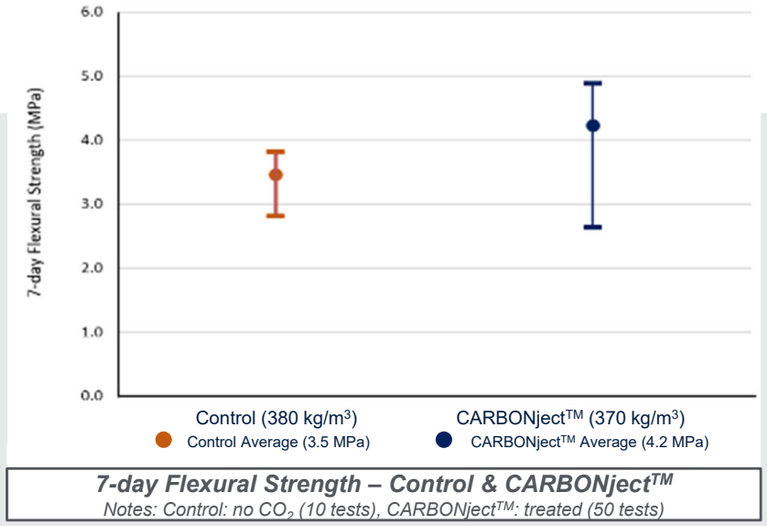



***7-day Compressive Strength – Control & CARBONject™***
*Notes: Control: no $CO_2$ (10 tests), CARBONject™: treated (101 tests)*

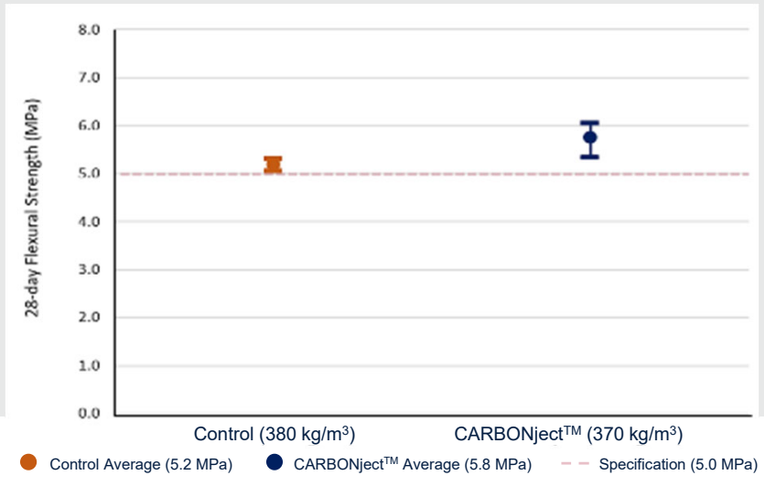



***28-day Compressive Strength – Control & CARBONject™***
*Notes: Control: no $CO_2$ (10 tests), CARBONject™: treated (101 tests)*

FLEXURAL STRENGTH




***7-day Flexural Strength – Control & CARBONject™***
*Notes: Control: no $CO_2$ (10 tests), CARBONject™: treated (50 tests)*




***28-day Flexural Strength – Control & CARBONject™***
*Notes: Control: no $CO_2$ (10 tests), CARBONject™: treated (50 tests)*

- Mixes treated with CARBONject™ demonstrated accelerated (early) strength development
- In this case study, the control mix has higher cement content – indicating that the gains from CARBONject™ would be better if compared to a like-for-like cement content

# What's next for CARBONject™

**Continue to refine the injection process to increase $CO_2$ conversion to Calcium Carbonate**

**Looking at other admixtures that enhance the capture of $CO_2$ and the conversion to Calcium Carbonate**

**Working with developers to include the CARBONject™ solution in residential buildings**

**Researching the combination of CARBONject™ with other low carbon concrete solutions (new cementitious products)**

# IN SUMMARY…

- CARBONject™ is an effective way to reduce the GWP content of any concrete product
- Concrete treated with CARBONject™ does not slow down the reaction, has no effect on workability or placement, nor does it require special construction methods
- New admixtures are showing signs of increasing the reaction and further reducing the $CO_2$ footprint
- CARBONject™ is one of many low carbon concrete solutions being put into action at CRH
- By combining these solutions, we can further optimize the carbon reduction profile of the concrete

# Thank you