CARBON CURE™

SPECIFICATION CONSIDERATIONS FOR ENGINEERS

FROM CARBON TO SIMPLY BETTER CONCRETE

REDUCING EMBODIED CARBON IN CONCRETE USING SPECIFICATION BEST PRACTICES

CarbonCure is leading a global mission to reduce the carbon footprint of the built environment by using recycled CO_2 to improve the manufacturing process of the world's most abundant man-made material: concrete.

The CarbonCure Technology is installed in concrete plants across the world to inject waste CO_2 into concrete during mixing. Once injected, the CO_2 becomes chemically converted to a mineral and permanently embedded in the concrete.

Most importantly, CO_2 mineralization improves concrete's compressive strength, enabling concrete producers to reduce cement content while maintaining concrete performance criteria.

Engineers play a vital role in reducing embodied CO_2 by adopting concrete specification best practices.

> "There is an urgency to act now to reduce the embodied carbon in new construction developments. It's imperative that as designers, developers, and builders we support the rapid scaling of technologies, tools and processes that reduce carbon emissions from the manufacturing of building materials."

Stacy Smedley
Director of Sustainability, Skanska

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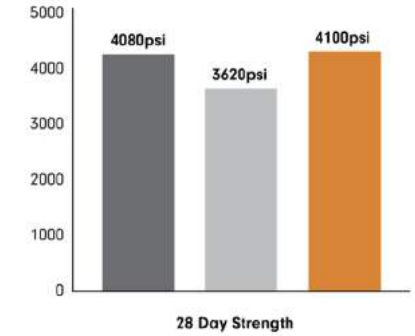
What Impact does the addition of CO_2 with CarbonCure have on cement content?

CO_2 improves the compressive strength of concrete, which enables ready mix producers to reduce cement content for most applications. Concrete producers are typically able to reduce 3% - 8% of cement content while maintaining the concrete's compressive strength, and without impacting other performance criteria. This may result in an increase in the water/cementing materials ratio by 0.01 – 0.04.

What does this mean for concrete specs?

Concrete specifications with minimum cement content or maximum water/cementing materials ratios may limit the concrete producer's ability to adjust cement content and therefore limit the concrete producer's ability to reduce the concrete's carbon footprint.

Case Study: Cement Reduction Potential with CO_2



Design Strength: 3000 PSI

50% OPC 20% Fly Ash 30% Slag

Control mix 4080 psi
Meets strength criteria

Cement reduced from mix 3620 psi
Strength reduced

Cement reduced and CO_2 added to the mix 4100 psi
Exceeds strength criteria

NRMCA
NATIONAL READY MIXED CONCRETE ASSOCIATION

National Ready Mixed Concrete Association (NRMCA) Recommendation

The NRMCA recommends engineers to consider optimizing their concrete specifications for sustainability, while maintaining the performance criteria of the project.

Minimum cement content in specifications

According to the NRMCA, minimum cement contents may be higher than necessary to meet strength. High quantities of cement may adversely impact placement and finish-ability, may increase potential for cracking due to plastic shrinkage and temperature, may increase alkali content, and will adversely impact the concrete's carbon footprint.

There is no requirement for minimum cement/cementitious content in ACI 318-14, which states that minimum cement/cementitious content is not needed for freeze-thaw durability, exposure to water-soluble sulfates, rebar corrosion protection, or mitigating ASR.

The NRMCA recommends that concrete specifications should avoid specifying minimum cement/cementitious content.

SPECIFICATION CONSIDERATIONS FOR ENGINEERS

Considerations for specifying a maximum water/cementing materials (w/cm) ratio

National Ready Mix Concrete Association recommendations

- Including a maximum w/cm for concrete where it is not essential can adversely affect the ability to place and finish concrete, and adversely affect the concrete's performance.
- A low w/cm does not assure reduced shrinkage.
- Avoid indicating a specified strength that is significantly lower than what might be expected for a specified w/cm.
- Maximum w/cm is controlled by exposure classes; avoid specifying maximum w/cm if it is not applicable to the anticipated service conditions of the structural members.
- Consider the use of ASTM C1202 (a standard test method for resistance to chloride ion penetration) to replace the w/cm with the following alternative criteria:
  - w/cm = 0.50 → 2500 coulombs
  - w/cm = 0.45 → 2000 coulombs
  - w/cm = 0.40 → 1500 coulombs

For more information on concrete specification best practices, visit www.nrmca.org

OPTIMIZING CONCRETE SPECIFICATIONS FOR SUSTAINABILITY CREATES RESULTS

The concrete specifications were optimized on **48,000 cubic yards** of concrete supplied to 725 Ponce in Atlanta. As a result, the project reduced embodied carbon by **1.5 million pounds of CO_2**. That's equivalent to an acre of forestland sequestering CO_2 for the next **800 years**.

"Uzun+Case, with input from Thomas Concrete, specified the CarbonCure Technology to reduce the carbon footprint of 725 Ponce. We're proud to have saved **1.5 million pounds of CO_2** while maintaining our high quality standards for concrete."

Rob Weilacher
Engineer of Record
Uzun+Case

SPECIFICATION CONSIDERATIONS FOR ENGINEERS

RECOMMENDED SPECIFICATION INSERT LANGUAGE – DIVISION 03 - CONCRETE

For incorporating concrete that has undergone in-situ Carbon Dioxide Mineralization using the CarbonCure Technology into concrete specifications and/or procurement.

IN-SITU CARBON DIOXIDE MINERALIZATION REQUIREMENTS

1. Environmental/Sustainable Design Requirements

1.1 In-situ carbon dioxide mineralization in concrete: Supply concrete that has undergone in-situ carbon dioxide mineralization, such that post-industrial carbon dioxide (CO_2) is injected into the concrete during mixing and chemically converted into a mineral. The concrete may undergo mix adjustment, whereby the strength enhancement property of CO_2 is utilized to optimize cementitious content, pending that the CO_2-mineralized and optimized concrete mix meets concrete performance requirements as outlined in this specification document. Acceptable technologies: CarbonCure Ready Mix Concrete Technology.

1.2 For Canadian projects see CAN/CSA-A23.1 Annex S, Concrete made with carbon dioxide as an additive (revised June 2018).

2. Verification

2.1 Provide concrete producer's verification of in-situ mineralization of CO_2.

3. Concrete Product with In-Situ Carbon Dioxide Mineralization

3.1 Minimum cementitious content and maximum water/cementing materials ratio requirement as outlined by this specification will be reviewed and may be adjusted by the Engineer pending review of submittal, if required. Adjustment of cementitious content and water/cementing materials ratio requirement will be at the sole discretion of the Engineer.

Waste CO_2 emissions are collected from local industrial emitters

The purified CO_2 is diverted to the concrete plant using the CarbonCure Technology.

The CO_2 is injected into the concrete mix, where it chemically converts to a mineral.

CarbonCure's producer partners deliver carbon-reduced concrete to local construction projects.