CARBON CURE™

Specification Considerations for Engineers

Reducing embodied carbon in concrete using specification best practices

CarbonCure's Concrete Solution

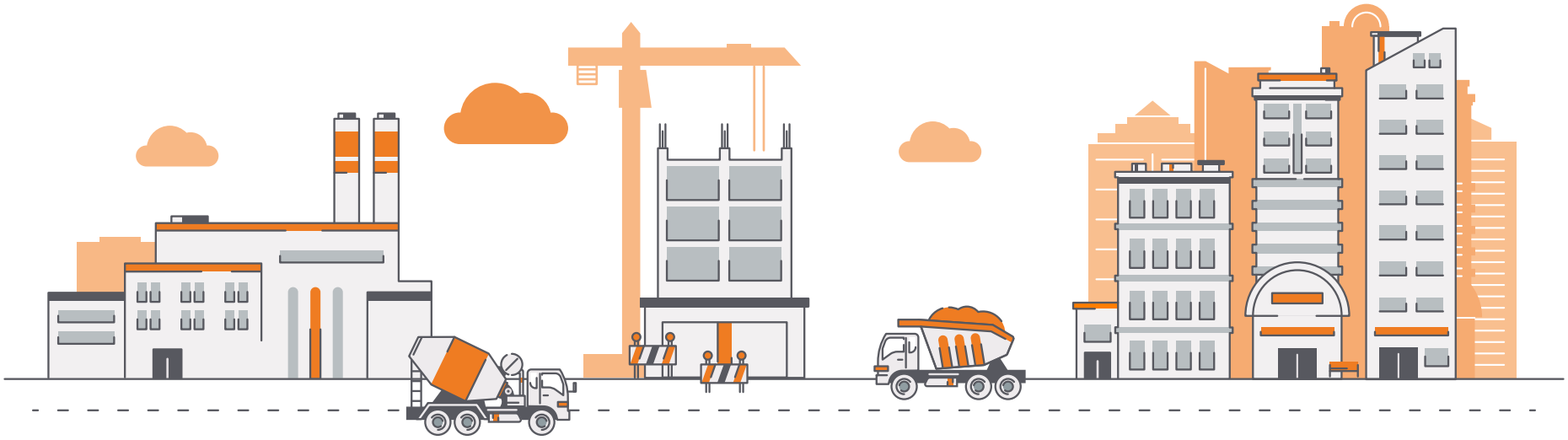
CarbonCure is leading a global mission to reduce the carbon footprint of the built environment by using recycled CO_2 to improve the manufacturing process of the world's most abundant man-made material: concrete.

CarbonCure 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



1. Waste CO_2 emissions are collected from local industrial emitters by gas companies and then purified.
2. The purified CO_2 is stored onsite at the concrete plant and connected to CarbonCure's technology.
3. CarbonCure's technology injects CO_2 into the fresh concrete to create high-performing, low-carbon concrete.
4. Private and public projects are built with CarbonCure concrete, reducing embodied carbon in new buildings.

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-cementitious materials ratio (w/cm) by 0.01 – 0.04.

What does this mean for concrete specs?

Concrete specifications with minimum cement content or maximum w/cm 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.

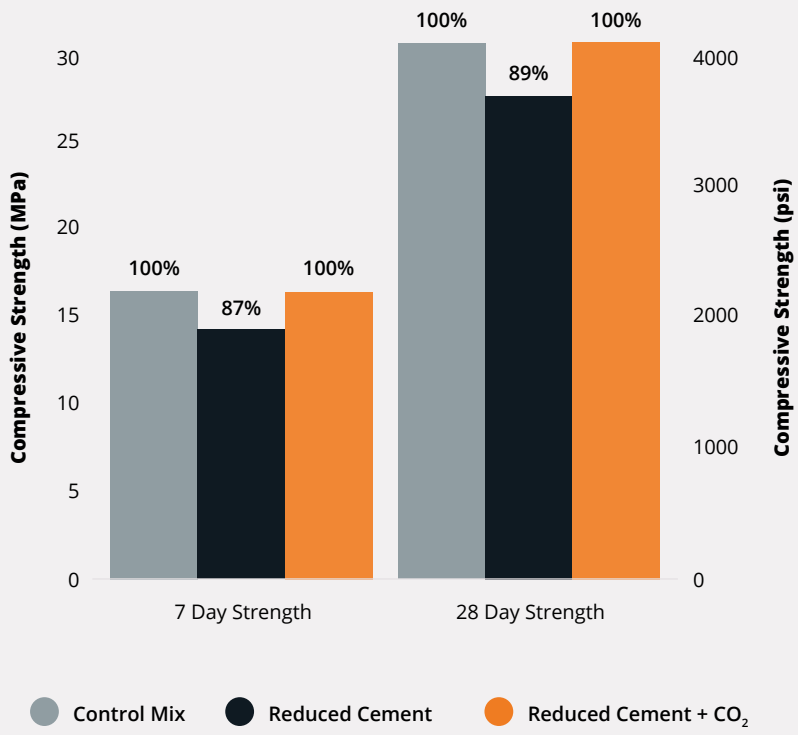
Minimum cement content in specifications

According to the National Ready Mixed Concrete Association (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. To learn more, review the resources in their Specification in Practice campaign.

Case Study:
Cement Reduction Potential with CO_2



Water-Cementitious Materials Ratio: NRMCA Recommendation

Including a maximum water-cementitious materials ratio (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

NRMCA Recommendation

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

NRMCA
NATIONAL READY MIXED CONCRETE ASSOCIATION

The SE 2050 Challenge

Structural engineers around the world are stepping up and accepting the SE 2050 Challenge. Already, **many large engineering firms** have endorsed the initiative: Arup, Walter P. Moore, and Thornton Tomasetti to name a few.

SE 2050 stands for the **Structural Engineers 2050 Commitment Initiative**. It encompasses both the SE 2050 Challenge issued by the **Carbon Leadership Forum** and the SE 2050 Commitment Program developed by the **Sustainability Committee of the Structural Engineering Institute** (SEI) of the **American Society of Civil Engineers** (ASCE).

The initiative was designed to spur structural engineers and their firms to take ownership of their role in reducing embodied carbon emissions in the built environment.

The initiative's ultimate goal is that, "All structural engineers shall understand, reduce, and ultimately eliminate embodied carbon in their projects by 2050."

SE 2050 signifies a changing attitude among structural engineers to remove barriers to innovation—like prescriptive specification—and an effort to develop stronger collaboration with the concrete industry.

Did You Know?
Embodied carbon is expected to account for **nearly half** of the total carbon footprint of new construction between now and 2050. In order to meet the Paris Agreement targets, we need to reduce embodied carbon by **50% by 2030**, and eliminate embodied carbon by 2050.

Reference Project: 725 Ponce

Atlanta, GA United States

Thomas Concrete delivered 48,000 yd^3 (36,700 m^3) of concrete made with CarbonCure for every application of this building. As a result, 1.5 million pounds (680 tonnes) of CO_2 were avoided; which is equivalent to 888 acres (360 hectares) of trees sequestering CO_2 for a year.

"Uzun+Case, with input from Thomas Concrete, specified CarbonCure 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

Building Description:
360,000 ft^2 (33,445 m^2)
mid-rise, mixed-use

Developer:
New City Properties

Concrete Supplier:
Thomas Concrete

Architect:
Cooper Carry

Structural Engineer:
Uzun+Case

General Contractor:
Brasfield & Gorrie

Completion:
2018

Recommended Specification Insert Language - Division 03 - Concrete

For incorporating concrete that has undergone in-situ Carbon Dioxide Mineralization using 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 optimization 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-cementitious 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.

Build for the Future.
Build with CarbonCure.

CarbonCure has been used on thousands of projects ranging from healthcare to higher education, home developments, and corporate campuses.

For more information about building with CarbonCure concrete, please contact a CarbonCure representative at **+1 (844) 407-0032** (toll-free) or send us an email at **info@carboncure.com**.