CarbonCure™ Concrete Additive

Product Description

CarbonCure Technologies offers a technology to implement carbon dioxide (CO_2) utilization in the ready mix concrete industry. Waste CO_2 can be put to a beneficial use as a feedstock in the production of concrete. The retrofit CarbonCure™ Ready Mix Technology adds CO_2 to concrete during mixing. The CO_2 reacts with the cement and is mineralized to produce nanoscale calcium carbonate. The carbonate formation can impart positive impacts on the concrete. The CO_2 addition (hereafter, CarbonCure) can improve hydration and increase compressive strength without affecting the fresh concrete properties.

Uses

CarbonCure is used to produce concrete mixes with higher compressive strength. CarbonCure is suitable for normal weight and light weight concrete in ready-mix applications. Concrete shall be designed in accordance with *Standard Recommended Practice for Selecting Proportions for Concrete, ACI 211*.

Benefits

The addition of CarbonCure to concrete mixes can realize benefits including:

- Ability to improve both-early and late-age compressive strengths
- Reduced variability of compressive strengths
- Optimized binder designs
- Concrete produced with reduced carbon footprint

Guidelines for Use

Dosage Rates: CarbonCure has a recommended dosage rate of 0.8 – 4.0 fl oz/cwt (50 – 250 g/100 kg) of cement (as distinct from total cementitious) for most applications. Dosages outside this range may be used if local testing shows acceptable performance. Pretesting is required to determine the appropriate addition rate for desired performance. The optimum addition rate may be influenced by other concrete mixture components, cement types, ambient temperature, mineral additives, quality and gradations of aggregates, slump of concrete, mixing equipment, job conditions, and desired performance characteristics

Mixing: The optimum performance of the CarbonCure is generally obtained with a delayed addition following the start of mixing.

Packaging and handling

CO_2 is available in bulk and delivered by tanker truck to an on-site pressurized storage tank for dispensing by means of the CO_2 metering equipment.

CO_2 must have a certified purity of 99% or above for use in this application – certification of CO_2 purity compliance shall be made available upon request. CO_2 safety and handling information can be found in Carbon Dioxide safety data sheet CAS No: 124-38-9.

Dispensing Equipment

CarbonCure is dispensed from a storage tank of liquid CO_2 in communication with the dispensing control system. The tank and CO_2 are sourced from a local industrial gas supplier. The tank capacity is determined according to the usage and gas supplier recommendation. The dispensing control system is connected to the batching system and the CO_2 addition is fully integrated into the batch sequencing of materials that are added to the mix.

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Performance Characteristics

Fresh properties

An optimal dose of CarbonCure does not impact concrete workability or air content. Producer data for production on a single mix design is presented for slump (**Figure 1**) and air content (**Figure 2**). The CarbonCure production data is presented against control limits for the mix when made without CO_2. The average metric and variability of the fresh properties of the concrete made with CarbonCure was comparable to and consistent with the reference production.

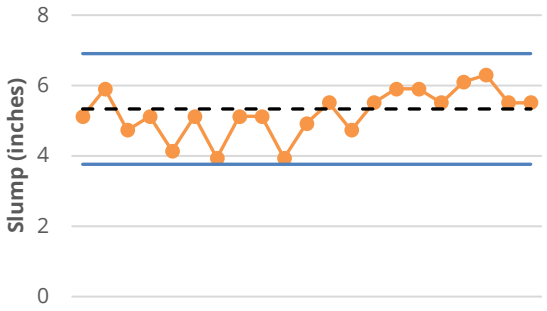

Figure 1: Slump comparison

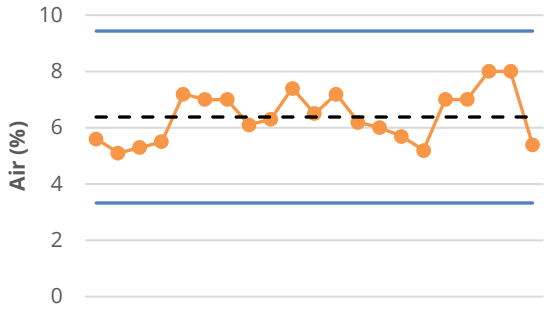

Figure 1: Air comparison

Compressive Strength

An optimal dose of CarbonCure can improve the compressive strength of the concrete at both early and late ages. Industrial strength data of concrete produced with two different CarbonCure dosages is presented in **Figure 3.**

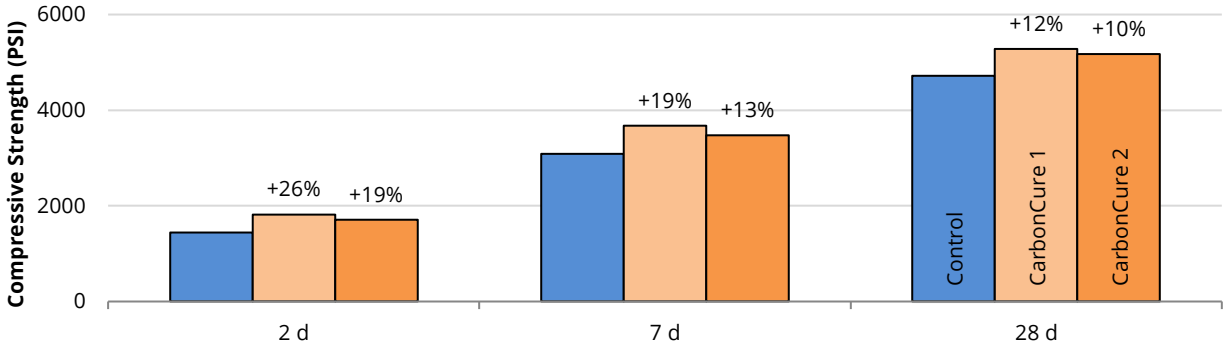

Figure 2: Compressive strength field data

Compatibility

CarbonCure is compatible with most admixtures used in the production of quality concrete, including normal, mid-range and high-range water-reducing admixtures, accelerators, retarders, extended set control admixtures, air-entrainers, corrosion inhibitors, and shrinkage reducers.

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Comment on Concrete pH

The reaction of atmospheric carbon dioxide with hydrated cement paste over time is acknowledged to consume calcium hydroxide and thereby reduce pore solution pH. Testing of the pore solution of concrete produced with CarbonCure was conducted at 28 days (Figure 4). The extracted pore solution was not affected by the CO_2 addition. The action of CO_2 in the earliest stages of hydration neither prevents nor impairs the later development of pore solution alkalinity.

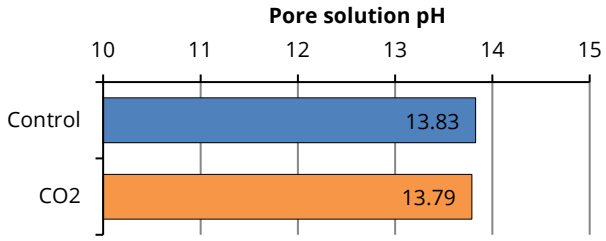

Figure 3: Pore solution pH measurement

Related Documents

See MSDS for carbon dioxide as provided by the industrial gas supply partner.

NOTE

Continuous testing by the concrete producer is strongly recommended. Since all cements and other concrete-making materials differ from source to source, and can vary over time, ongoing testing by the concrete producer is recommended for optimum CO_2 system performance, especially when changes are made to the materials or batch sequencing. Accurate concrete performance assessments require adequate quality control practices. The CO_2 injection system performance is supported through following all recommended maintenance practices, procedures and schedules.

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DIVISION 03 – Concrete Specification

RECOMMENDED SPECIFICATION INSERT LANGUAGE

For incorporating concrete that has undergone in-situ Carbon Dioxide CO_2 Mineralization using CarbonCure technology into concrete specifications and/or procurement policies.

DIVISION 03 – CONCRETE

INTRODUCTION

CarbonCure Technologies is the leader in reducing the carbon footprint of the built environment by incorporating recycled carbon dioxide (CO_2) into the concrete manufacturing process. CarbonCure's technology is currently installed in ready mix concrete producers across Canada, USA and Singapore.

The CarbonCure technology injects CO_2 (captured as waste from emitters) into concrete during the manufacturing process. Once injected, CO_2 chemically converts (in-situ) into a nano-mineral and becomes permanently captured in the concrete.

The in-situ CO_2 mineralization improves the compressive strength of concrete, allowing concrete producers to optimize mix designs and reduce cementitious content. Cement manufacturing generates ~7% of global CO_2 emissions. Reductions in cementitious content decrease concrete's carbon footprint. Cost savings from cementitious reductions offset concrete producer's costs of adopting the technology.

Utilizing CO_2 to optimize cementitious content may require adjustment to specification requirements for minimum cementitious content and/or maximum water-cementitious ratios, as approved by project engineers and designed by concrete producers.

Developers, engineers, architects, specifiers and contractors may reduce the carbon footprint of concrete used in building or infrastructure projects, while ensuring equivalent performance, by requesting concrete that has undergone *in-situ carbon dioxide (CO_2) mineralization* in the specification language.

This document is provided in MS Word to allow for copying and/or modification of specification language, at the discretion of the engineer, architect or specification writer.

Further information about CarbonCure Technologies can be found at www.carboncure.com.

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1. IN-SITU CARBON DIOXIDE MINERALIZATION REQUIREMENTS

1.1 ENVIRONMENTAL / SUSTAINABLE DESIGN REQUIREMENTS

1.1.1 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.

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

1.2 VERIFICATION:

1.2.1 Provide concrete producer's verification of in-situ mineralization of carbon dioxide.

1.3 CONCRETE PRODUCT WITH IN-SITU CARBON DIOXIDE MINERALIZATION

1.3.1 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.

1.4 CARBONCURE REFERENCE AND CONTACT INFORMATION

1.4.1 For CarbonCure ready mix concrete product availability and regional contact information, visit www.carboncure.com/producers.

1.4.2 For general inquiries contact info@carboncure.com or 902-442-4020.

END OF SECTION

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

SPECIFICATION CONSIDERATIONS FOR ENGINEERS

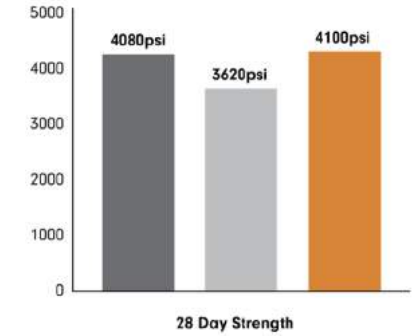
What Impact does the addition of CO_2 with CarbonCure have on cement content?

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

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 **800 acres** of forest sequestering CO_2 for a year.

"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.

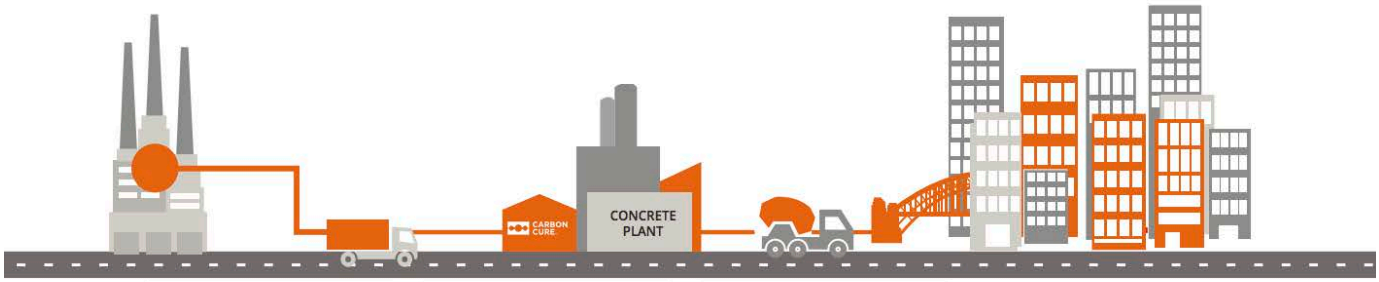
1.2 For Canadian projects see CAN/CSA-A23.1 Annex S, Concrete made with carbon dioxide as an additive (revised June 2018).

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.



1. Waste CO_2 emissions are collected from local industrial emitters.
2. The purified CO_2 is diverted to the concrete plant using the CarbonCure Technology.
3. The CO_2 is injected into the concrete mix, where it chemically converts to a mineral.
4. CarbonCure's producer partner delivers its carbon-reduced concrete to local construction projects.