What matters most to reduce CO_2 in concrete?

Cement. It's not news to any of us that cement is the key ingredient in concrete - along with water, admixtures, aggregates, and supplementary cementitious materials - but if you want to really impact the carbon footprint of a mix, you've got to focus on cement.

In most typical mixes - like this listed here by the NRMCA industry standard EPD - cement contributes about 80% of the total score of global warming potential (GWP).

This is followed by the use of slag, 17.4%, coarse aggregate contributing 1.5%, and fine aggregates, 1.0%. The table below shows it comparatively - in this 30 Mpa mix design, cement's CO_2 emissions are huge compared to the other components of the mix.

Table 1. CO_2 emission C-I-49 project

Category	C-1-49 (30 MPa-500 mm slump)	
	Mix Design (kg/m³)	CO_2 Emission
Ordinary Cement	211	196.44
Water	160	1.12
Coarse aggregate	953	3.81
Fine aggregate	806	2.42
Blast-furnace slag powder	211	43.04
Admixture	4.01	1.00
Flyash	Not Included	Not Included

CO_2 Emission Factor

CO_2 emission factor is a parameter representing the amount of CO_2 released into the atmosphere as a result of a specific activity, process, or unit of energy produced or consumed. The table illustrates the CO_2 emission factors for all the different components used in a concrete mix design. Considering the inherent ratios of each constituent and their corresponding CO_2 emission factors, impacting cement is key to enhancing the CO_2 efficiency of the entire mix.

Table 2. CO_2 emission factors

Category	CO_2 Emission Factor
Cement (IL)	0.820[1]
Water	0.007[2]
Coarse aggregate	0.004[2]
Fine aggregate	0.003[2]
Admixture	1.880[3]
CO_2	0.1063

[1] Miller 2018
[2] Climate Earth
[3] EFCA 2015

CarbonCure for Ready Mix uses mineralization technology to inject captured CO_2 into concrete during the mixing process. Once injected, the CO_2 is chemically converted to a mineral and permanently embedded in the concrete — removing it from the atmosphere.

The CO_2 triggers additional reactions during the cement hydration process in the CarbonCure mix, leading to the formation of nano calcite particles. These particles reduce the porosity of the concrete and provide more sites for cement hydration, resulting in better cement hydration efficiency. Additionally, the calcite nanoparticles could react with alumina present in the cement or supplementary cementitious materials (SCMs) to form carboaluminates, thus enhancing the hydration reaction in the concrete.

We've reviewed the optimum performance of SCMs before - the by-products of other industries that can replace the cement portion of concrete, thereby offering sustainability advantages - but the injection of CO_2 offers another opportunity to make cement as efficient as possible in concrete. And, injected CO_2 has no incompatibility issues with SCMs.

Table 3. Customer example

	Control - 4000 psi, 3-in slump		CCT - 4000 psi, 3-in slump	
Category	Mix Design (lb/yd^{3})	CO_2 Emission	Mix Design (lb/yd^{3})	CO_2 Emission
Cement (IL)	520	426.24	495	405.75
Water	250	1.75	238	1.67
Coarse aggregate	1690	6.75	1717	6.86
Fine aggregate	1535	4.60	1559	4.67
Admixture	1.625	3.06	1.563	2.94
CO_2	–		1	0.11
Total		**442.40**		**421.88**

This customer case demonstrates a 4.6% reduction in CO_2 emissions at the mix level, mainly attributable to a 4.8% reduction in cement consumption due to the utilization of CarbonCure.

As we explore ways to enhance the CO_2 efficiency of concrete mixes, the adoption of innovative technologies like CarbonCure that directly impact cement has the potential to significantly reduce CO_2 emissions in concrete production.