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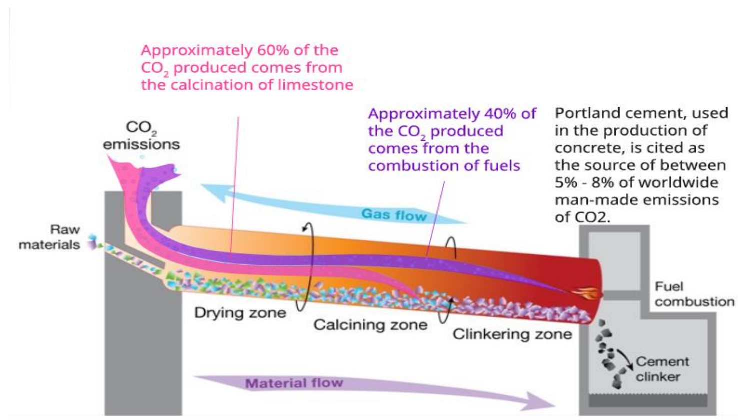
Welcome to Concrete Solutions, a quarterly publication of concrete related topics. This edition focuses on the importance of carbonation also known as carbon dioxide uptake and its effect upon concrete life cycle assessment. EPD is another industry acronym becoming more commonplace as specifiers are requiring them and in some states are mandated by law for certain building products, but what exactly is an EPD?

CARBONATION AND CONCRETE LIFE CYCLE ASSESSMENT

Concrete buildings, pavements and structures are silently absorbing carbon dioxide from the atmosphere. It appears to such a degree that the **built environment represents one of the world's largest storehouses of carbon**. Yet this information is currently excluded from global, national, and regional greenhouse gas accounting methods. As countries, municipalities, and companies establish and strive to achieve greenhouse gas emission reduction targets, it is imperative to ask, what is the true value of CO_2 emissions from concrete within the built environment? This is a question that is being asked as researchers look for ways to minimize the release of, and optimize the capture and sequestration of CO_2 in the atmosphere.

Concrete, the world's most popular building material, constitutes a large portion of the global built environment. The production of Portland cement, which is an ingredient of concrete, is commonly identified as a major contributor to greenhouse gas emissions. Often the story ends there. CO_2 emissions occur when calcium carbonate, the main component of limestone, is exposed to intense heat as part of the cement production process. These emissions come from both the burning of fuels used to heat the cement kiln and from the CO_2 released from the raw carbonates used to make cement. This process is called calcination.



Calcination: $CaCO_3$ (limestone) + Heat → CaO (quick lime) + CO_2

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Figure A- Calcination process of cement

The process of calcination is not chemically stable and therefore is reversible. CO_2 in the atmosphere reacts with the hydrated cement in concrete and carbonates are regenerated. **Exposed concrete in the built environment absorbs carbon dioxide** through the reaction of CO_2 with concrete compounds resulting in $CaCO_3$, the main component of limestone. **This reaction permanently removes CO_2 from the atmosphere and binds it in a stable state within concrete. This process is called carbonation.**

Considerable attention has been paid to quantifying the industrial process emissions from cement production, however the natural reversal process of the uptake of CO_2 throughout the duration of concrete's material life phases is just beginning to receive the consideration it deserves. Concrete is a significant CO_2 sink and therefore should be included in the determination of net environmental emission calculations as such by evaluating all structures over their lifetime within a circular economy.

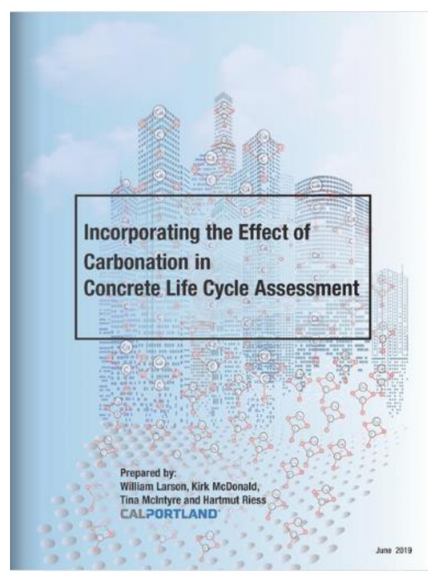
In the past few decades there have been many studies that have examined factors affecting the capacity of concrete to absorb carbon dioxide from the atmosphere. One of the more recent studies from the Swedish Environmental Research Institute (SERI) examined data from several European countries to develop practical models to measure the extent of CO_2 uptake by concrete globally in the built environment. The researchers developed several approaches and statistical models of increasing complexity to come up with valid estimates of general CO_2 uptake by concrete. The Tier 1 model provides a simplified approach for use on a national basis relative to the annual emissions associated with cement production in the same year. It has two options for the calculation of CO_2 uptake. Option A uses the mean value of 20% for estimating uptake of CO_2 over the life of concrete structures. Option B uses this mean value minus a standard deviation factor for estimating CO_2 uptake resulting in 15% uptake.

The standard deviation adjustments are designed to account for various factors that could affect the rate of carbonation. Such factors include the length of time of exposure to the atmosphere, humidity, porosity of the concrete, cement type, and water to cement ratios.

Figure B- Material life phases of concrete: recycled concrete, recycled concrete base, and landfill concrete.

Many organizations and companies are actively working on measures to reduce greenhouse gas emissions. Having a better appreciation of the level of CO_2 uptake by concrete can help us develop better strategies to mitigate the impacts of climate change. As this paper and several noted studies clearly show, **carbonation in cement products represents a substantial carbon sink that is not currently considered in emissions calculations.**

The efforts of CalPortland's researchers illustrates that to understand the effects of greenhouse gases associated with the built environment, focused studies on CO_2 uptake in concrete within the context of its overall Life Cycle Assessment (LCA) are necessary. To read or download the full paper, Incorporating the Effect of Carbonation in Concrete Life Cycle Assessment, please follow this link: https://www.calportland.com/incorporating-the-effect-of-carbonation-in-concrete-life-cycle-assessment/



ENVIRONMENTAL PRODUCT DECLARATION (EPD)

The construction industry has begun producing Environmental Product Declarations, or EPDs, to meet the growing demand for greater sustainability in response to climate change concerns. If you are not familiar with EPDs, to put it simply, an EPD measures the environmental footprint of a product.

In the construction industry, an EPD is a life cycle assessment tool for a building product, like concrete. The assessment is conducted by a manufacturer in compliance with a product category rule (PCR) and verified by a third party. Builders, architects and specifiers use EPDs when deciding what products to utilize to construct sustainable buildings.

What should we know about EPDs? Basically, an EPD tells a product's life story through a whole life cycle assessment. This is important when establishing a product's emissions and impact on the environment. The product life cycle known as "Cradle to Cradle" begins with the extraction phase to manufacturing and then product transportation, through its useful life and finally to product disposal at the end of life. By looking at a product's entire lifespan we can better discuss how that product will affect the environment. Current EPD reporting only focuses on "Cradle to Gate" emissions only in the Product Stage. (Figure C.) Project CO_2 emissions emitted during the construction, use, and end of life stages are not accounted for in current carbon accounting practices of EPDs.

TYPICAL LIFE CYCLE STAGES OF CONCRETE

LCA

EPD

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE			
Extraction and upstream production	Transport to factory	Manufacturing	Transport to site	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction/ demolition	Transport	Waste processing	Disposal of waste
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4

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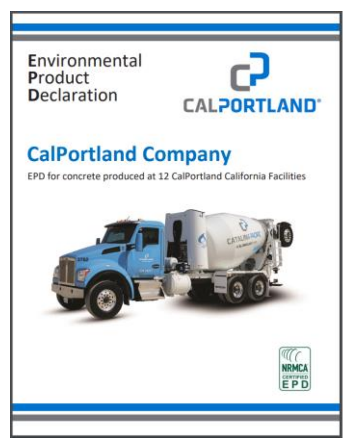
Figure C- Life Cycle Stages of Concrete

The term embodied carbon is used often when discussing CO_2 emissions. Embodied carbon refers to the emissions associated with building construction including extracting, transporting, and manufacturing materials. It is important to look beyond the embodied carbon emissions that are locked in place as soon as a building is constructed. Material selection can then be assessed including embodied carbon emissions and the operational energy of the building. While embodied carbon is important, to fully understand the environmental impact of products in a circular economy we must include all aspects of construction, operational use, end of life and secondary use of materials.

By utilizing EPDs generated with a focus on full life cycle assessment of a product, we can understand a projects full environmental impact and make better informed building product selections.

To view available CalPortland EPDs for concrete, please visit https://www.calportland.com/products/concrete/



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