RECARBONATION

HOW CONCRETE LOCKS UP AND STORES CARBON DIOXIDE - PERMANENTLY

It is well known that plants absorb carbon dioxide by photosynthesis and therefore forests act as a global sink for carbon dioxide. Far less well known is that the concrete in our built environment, in our cities and infrastructure, also absorbs carbon dioxide. Unlike forests, which release their carbon dioxide into the atmosphere when felled, concrete stores carbon dioxide permanently.

To understand why, we need to understand what concrete is and how it is made. Concrete is the most widely used manmade material, made by mixing aggregates (crushed rocks) and sand with cement and water. Cement, the material which binds concrete, is made by heating limestone to very high temperatures up to 1450°C. This breaks down the limestone into calcium oxide, the key ingredient of cement, and carbon dioxide. This reaction is called calcination and accounts for approximately two-thirds of the carbon dioxide emissions from cement manufacture. Burning fuel in the kiln to obtain the very high temperatures needed, accounts for the other third of carbon dioxide emissions. Currently all the carbon dioxide is released into the atmosphere, but in future we plan to capture it and either re-use it or permanently store it. After the concrete has been produced, the calcination reaction naturally reverses. The concrete starts to reabsorb carbon dioxide from the atmosphere, mineralizing the concrete and enhancing its stone-like properties. This process, called recarbonation, occurs in all concrete structures - buildings, pavements, tunnels, dams, bridges - throughout their life. Mortar, which is made by mixing sand with cement and water, also recarbonates.

The science of recarbonation is well established and already included in standards for calculating the carbon footprint of concrete buildings, structure and products, although not yet in Kyoto Protocol National Greenhouse Gas Inventory Reports. For an individual concrete product or structure, around 75% of the carbon dioxide emitted by the calcination reaction will eventually be reabsorbed by recarbonation – but the timescale over which this occurs varies from a few months or years to hundreds of years[1,2]. For National Inventory Reporting of carbon dioxide emissions and removals to the United Nations Framework Convention on Climate Change (UNFCCC) under the Kyoto Protocol, a different, more complex, calculation is required – the amount of carbon dioxide absorbed by recarbonation for all the concrete in the reporting country in the reporting year. A recent international review showed that, as a first approximation, this is around 23% of the annual calcination emissions from cement consumed in the year[3].

How quickly recarbonation occurs depends on multiple factors, including the strength and porosity of the concrete. Mortar recarbonates very rapidly whereas reinforced concrete structures are designed to recarbonate extremely slowly (to avoid any corrosion of the steel reinforcement). When concrete is demolished and crushed, its surface area is vastly increased and recarbonation occurs at a much

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[1] BSI Standards Publication, 2017. BS EN 16757:2017 Sustainability of construction works - Environmental product declarations - Product Category Rules for concrete and concrete elements.

[2] BSI Standards Publication, 2019. PD CEN/TR 17310:2019 Carbonation and CO_2 uptake in Concrete.

[3] Stripple, H., Ljungkrantz, C., Gustafsson, T., Andersson, R., 2018. CO_2 uptake in cement-containing products (No. B2309). IVL.

faster rate. Recarbonation continues when concrete is recycled, for example into roadbase. How concrete is handled in the demolition, crushing and recycling stages determines how quickly it recarbonates. Storing crushed concrete in large stockpiles with little air circulation and only for short periods, will inhibit recarbonation. By optimizing demolition practices to facilitate rapid recarbonation, significant quantities of carbon dioxide can be permanently locked up in the mineralized crushed concrete before it is reused and recycled.

Researchers are also developing industrial technologies to accelerate and enhance recarbonation. Carbon dioxide can be used to cure fresh concrete and to accelerate the recarbonation of crushed demolition concrete to create improved recycled aggregates. Such technologies could be an effective means of utilizing and permanently storing the carbon dioxide captured from cement manufacturing.

Elsewhere on this website, we explain how the industry is innovating to reduce emissions, and to capture the carbon dioxide produced by the chemical breakdown of limestone during cement manufacturing. If we want to know the true carbon footprint of the cement industry, we need to remember that cement is turned into concrete buildings and structures, cities and infrastructure, which permanently capture carbon dioxide by the natural process of recarbonation.