# Technology in Practice

## What, Why & How?


## TIP 22 - Reducing Embodied Carbon in Concrete Mixtures

*This TIP discusses options for reducing the carbon footprint of concrete with equivalent performance while proportioning mixtures.*

### WHAT is Embodied Carbon in Concrete?

Embodied carbon in a construction project is the amount of carbon dioxide equivalent, $CO_2e$, (aka "carbon") associated with the extraction, processing, manufacturing, transportation, and installation of building products. This is also referred to as global warming potential (GWP). For concrete, it includes the carbon associated with extraction, handling, processing of the concrete materials, transportation of materials and fuel to the concrete plant, to batch and mix the concrete and operate the concrete plant. It is quantified as the mass (usually kg) of $CO_2e$ per unit volume of concrete (usually cubic yard or cubic meter) in an Environmental Product Declaration (EPD). Carbon footprint associated with materials used and production varies and the GWP will be unique to concrete with specific composition and strength level produced at a specific location.

Although portland cement production is one of the most energy efficient manufacturing processes, typically, over 80 percent of the embodied carbon in concrete is from cement, or more specifically from clinker in cement. This is associated with calcining of limestone and burning of fossil fuels required to achieve high kiln temperature of around 2600°F [1450°C] during its manufacture. Portland cement constitutes 10 to 15% by weight of concrete.

Although the discussion in this TIP is about embodied carbon, concrete buildings and pavements have a lower carbon footprint through their life cycle compared to alternative building materials due to improved energy efficiency from thermal mass effects in buildings, higher albedo reducing temperature rise surrounding pavements and roofs, increased service life, and benefits associated with absorbing atmospheric carbon dioxide (carbonation) during service life and at the end of life when concrete is crushed. Embodied carbon, however, is typically the focus during the design and construction of new buildings and infrastructure.

### WHY is Embodied Carbon in Concrete of Interest?

Emissions of carbon dioxide from industrial, energy generation, and other sources, that increases its concentration in the atmosphere is attributed to one of several factors that has increased average global temperature and caused climate change. There are several initiatives by governmental bodies at the city, state, and federal level; and by designer organizations, including architects and structural engineers, to reduce the embodied carbon in new construction.

More broadly, sustainable development has been a goal of the design community at least since the formation of the US Green Building Council in 1993 and the development of the LEED rating system. Sustainable development includes many factors such as a reduction in global warming potential (embodied and operational carbon), reduced energy use, resource conservation through increased use of recycled materials, and initiatives to support clean air, clean water, and low impact development. Embodied carbon, or GWP, is one of the primary factors that is quantified and targeted for reduction. For new construction, LEED Version 4.1 offers up to 6 points for reducing embodied carbon of products (2 points) and the whole buildings (4 points) when compared to baseline values. Concrete producers will be increasingly required to show reductions in embodied carbon in concrete. Concrete has an advantage whereby each mixture used for a building is considered a product.

**8 pages**