Resolution

WHEREAS, in May of 2021 the Town of Brookline declared " a Climate Emergency, recognizing the truth about the climate crisis and what it demands of us: an emergency response at emergency speed;" and

WHEREAS, more than 10 billion tons of concrete are produced annually around the world, making it second only to water as the most commonly used substance on the planet; and the production of cement, a major component of concrete, accounts for an estimated 9-10% of worldwide greenhouse gas emissions; put another way, for every ton of concrete produced, a ton of CO2 gases are emitted; and

WHEREAS, demand for concrete is projected to increase by more than 20% by 2050; and

WHEREAS, low-carbon concrete is available, and products are under development and beginning to enter the market, which enable concrete to remove CO2 gases from the air, which could make concrete a carbon sink rather than a source; and

WHEREAS, the market is nascent, we can help to build it through publicity and purchases; and

WHEREAS, the Town purchases tons of concrete per year for sidewalks, roads, and structures

NOW THEREFORE BE IT RESOLVED that the Town of Brookline use currently available low-carbon concrete products wherever feasible and encourage developers to do the same for any new construction. For this proposal, low-carbon products are defined as those that produce at least 10 percent less carbon dioxide emissions in their production and use, than the average mixture used for a given application. The town will also provide a low-carbon fact sheet to potential bidders.

BE IT FURTHER RESOLVED THAT the Town recycle old concrete wherever possible.

Explanation

Concrete does not get a lot of attention in the fight against global warming—solar power, wind turbines, electric vehicles, and minisplit heat pumps get all the headlines—and deservedly so. The savings from those measures are categorized as operational carbon. The other category is called embodied carbon—that is the greenhouse gas emissions associated with materials and construction processes throughout the lifecycle of a building or infrastructure. Over a 30-year operating period, embodied carbon can account for as much as half of a building's carbon emissions.[i] And concrete is a major source of embodied carbon—it is second only to water as the most commonly used material in the world, and as such it contributes as much as 10% of the CO2 filling up our atmosphere.

Where does the CO2 in concrete come from

Concrete consists of cement, aggregates (typically sand and gravel), and water. Producers may also include additives that determine the properties of the finished product. Cement, typically Portland Cement, is the major culprit in creating greenhouse gases (CO2). It is made by heating a combination of limestone and clay to a high temperature (~1450 deg C) in a kiln to form what the industry calls

"clinker". The clinker is crushed and mixed with additives such as gypsum to form cement. The kiln is typically powered by fossil fuels, accounting for about 40% of embodied CO2 in concrete. But more than half of embodied CO2 comes from the chemical reaction (calcination) that takes place, which releases large amounts of CO2. About 10% comes from mining and transport.[ii]

How is embodied carbon reduced?

Some approaches to carbon reduction are commercially available, while others are emerging that have the potential to make concrete carbon neutral or even a net carbon sink in the future. Commercially available approaches include steps that producers have taken to improve the thermal and electrical efficiency in their operations, and to use low-carbon fuels in their cement kilns. (eg replacing coal with biomass; or waste fuels such as shredded tires; which would otherwise be incinerated or put into landfills) [iii] At the end of the product life cycle, concrete from demolition can be used to produce recycled aggregates to be used in new concrete manufacturing.[iv] The transport infrastructure of concrete can also be decarbonized.[v]

The cement industry is also marketing a lower CO2 cement — Portland-limestone cement , a blend that adds extra limestone to the mix, lowering the amount of cement used in concrete and reducing its CO2 footprint by about 10%. In addition, Lehigh Cement of Canada produces concrete mixtures that incorporate EcoCemPLC which also reduces the CO2 emissions by as much as 10%.[vi]

Another approach currently in use is to reduce the amount of clinker used by substituting other materials—the clinker-to-cement ratio can reportedly be reduced by up to around 60% without sacrificing key cement or concrete properties.[vii] Fly ash and furnace slag have been common options, but scarcity of materials (eg less coal burned means less fly ash available) can make this a challenging approach in some areas. Alternatives are emerging that could increase the use of substitute materials. For example, a new plant in Connecticut is using recycled glass that can be used to replace up to half of the clinker content in Portland Cement. The supplier hopes to qualify for incentives under consideration by the New York State legislature.[viii]

Other emerging technologies fall into the category of carbon capture and sequestration, or more recently, capture and use. For example CarbonCure Technologies developed a process that removes CO2 from the production of cement and injects it into concrete during the mixing phase. The resulting concrete is stronger and has so far provided a net carbon reduction of about 5 to 7%.[ix] The company estimates that it has sent over a million truckloads of its product to construction sites, according to a recent New York Times article—while keeping almost 100,000 metric tons of CO2 out of the atmosphere. [x] NRDC reports that the company's technology is now deployed in nearly 400 concrete plants in North America and globally.[xi]

In another example, Solidia Technologies has developed a cement formula that can be fired at lower temperatures, cutting fossil fuel emissions by a third. Waste CO2 from other processes is then injected into the concrete mix as in the CarbonCure approach, reportedly achieving carbon reductions of up to 70%.[xii] The CO2 injection also replaces a lot of the water that is used in concrete production.

The challenge will be to scale up these technologies at a reasonable cost.

Researchers are also looking at ways to broaden recycling options. For example, the ReCreate project in northern Europe, explores ways to remove concrete elements from condemned buildings, without damage, for use in new buildings.[xiii]

Other companies working to reduce embedded carbon in concrete include: Blue Planet, CarbiCrete, U.S. Concrete, and Biomason

But even using just available technologies can have a big impact. For example, one analysis estimates that switching to a cement that's even 10% to 15% less carbon intensive than conventional, just for the highway and bridge modernization parts of a Biden infrastructure plan, would cut emissions by the equivalent of taking 500,000 to 750,000 cars off the road for a year.[xiv]

What are the barriers to widespread use

The industry must leap several hurdles for low-carbon concrete to become widely used, including:[xv]

--Safety concerns regarding the use of new approaches—new materials must go through strict long-term testing before they are accepted by the construction industries

--New methods of specifying concrete would need to be developed—performance specs that spell out strength, dry time and other parameters would replace the current use of prescriptive standards that call for specific content

--producers would face added costs for materials and equipment

What are other jurisdictions doing?

Governments are playing a role in getting more low-carbon concrete into the market. The Natural Resources Defense Council (NRDC) has identified green procurement initiatives as a way to use the purchasing power of the government to build markets for low-carbon industrial products like concrete, and help to develop market-wide standards.[xvi] In Germany, Bidders for public contracts are required to evaluate carbon emissions as well as other environmental impacts of primary building materials used in a project.[xvii] In the US, national infrastructure proposals have not addressed concrete, but several states and municipalites are active in that area. Marin County, Calif., adopted a building code that specifically requires limited carbon emissions from concrete, as opposed to providing incentives for that measure. In Seattle, the city's Green Building Standard offers expedited permitting for projects that meet embodied carbon criteria.[xviii]

In New York a bill to establish guidelines requiring the procurement of low-carbon concrete for state projects and set up a stakeholder advisory group to consider how to create incentives for green concrete production has passed both houses of the legislature. The bill also calls for consideration of developing performance-based standards as opposed to requiring that a structural material be produced using a specified manufacturing process.[xix]

In New Jersey, the legislature passed a bill that would provide tax incentives to builders that use low-carbon concrete. It would also require that builders offer concrete products that use "carbon footprint-reducing technology" as an option in new construction. It also requires the Commissioner of Community Affairs to publish educational materials concerning unit concrete products that utilize carbon footprint-

reducing technology, and provide developers with information concerning the tax incentives established in the bill.[xx]

In California, legislators are working on a bill that would call for the California Air Resources Board to develop a strategy to cut greenhouse gases from the cement and concrete industries by 40% by 2030, and to reach carbon neutrality no later than 2045. [xxi]

Financial impact

The cost premium for low carbon cement will vary with the application the degree of carbon reduction, and the approach used to achieve that reduction. The most expensive products can be twice the price of conventional cement according to one analyst. But NRDC predicts that the market will grow as the techniques are scaled up, and prices will drop.[xxii] Anecdotal evidence shows that it is possible to achieve significant carbon reductions with little cost increment. For example, Rocky Mountain Institute (RMI) describes a case where a 200,000 sq ft office building of concrete and steel, reduced embodied carbon by 46% with less than a 0.5% cost premium. Concrete accounted for 32% of that reduction through the purchase of concrete with lower cement content and allowing longer time to strengthen.[xxiii]

A report from MIT's Concrete Sustainability discusses options if the lowest impact product also possesses the highest cost. "A common solution is to set an environmental impact threshold for products; the lowest cost vendor whose product is below the threshold is chosen. Selecting the thresholds can be difficult because they need to be based on functionally equivalent product categories, which can be challenging for concrete mixtures." The report also notes that some states have taken more nuanced approaches. The proposal in New York state, for instance, allows the selection of concrete with up to a 15% higher cost if that concrete utilizes captured carbon."[xxiv]

Concrete in Brookline

The Town uses concrete for a variety of purposes. Brookline maintains 149 miles of sidewalk and 2111 curb ramps, of which 115 miles of sidewalk and 1950 curb ramps are made of concrete. The spec for sidewalk concrete is prescriptive, spelling out the contents of the concrete. [xxv] The Town has also prepared a bid document for work on the Larz Anderson Park Lagoon Structure project which calls for several types of concrete and specifies compliance with specific American Concrete Institute standards.[xxvi]

For the 3-year period June 1, 2021 through May 31, 2024 the Town has issued a request for bids for four different types of ready mixed concrete. The total quantity called for, 1320 cubic yards, (CY) represents an estimate of the Town's expected needs. Converting CY to tons and using a rough estimate that producing 1 ton of concrete releases 1 ton of CO2 into the atmosphere, we find that Brookline's use of concrete over a three-year period releases about 2700 tons of CO2. Using the Environmental Protection Agency's equivalence calculator, we can estimate that quantity is equal to the amount of CO2 released by 533 passenger cars driving for a year.[xxvii] A ten percent decrease would be the equivalent of taking more than 50 cars off the road for a year.

[i] Carbon reduction in construction: a net benefit, not just to the environment, but to the bottom line | www.usa.skanska.com
[ii] Q&A: Why cement emissions matter for climate change | Carbon Brief
[iii] Climate works
[iv] Concrete > Mission Possible Partnership
[v] A net-zero world needs zero-carbon concrete. Here's how to do it | World Economic Forum (weforum.org)
[vi] Low Carbon Concrete — Starting from the Ground Up | CleanTechnica
[vii] Climate works
[viii] Low-Embodied-Carbon Concrete Options Set to Benefit from Proposed New York Law | 2020-12-17 | Engineering News-Record (enr.com)

[ix] New York State Embodied Carbon Concrete Leadership Act (environmentalleader.com)

[x] Has the Carbontech Revolution Begun? - The New York Times (nytimes.com)

[xi] With Carbon Capture, Concrete Could One Day Be A Carbon Sink | NRDC
[xii] Rolling Stone article; The future with lower carbon concrete | New Scientist
[xiii] Major international project launched to develop solutions for reusing precast concrete elements in new buildings (helsinkitimes.fi)
[xiv] Concrete Still a Barrier to Climate-Friendly Infrastructure Plan (bloomberglaw.com)

[xv] Q&A: Why cement emissions matter for climate change | Carbon Brief
[xvixvi]

[xvii] Green-Public-Procurement-Final-28Aug2019.pdf (climateworks.org)
[xviii] Low-Embodied-Carbon Concrete Options Set to Benefit from Proposed New York Law | 2020-12-17 | Engineering News-Record (enr.com)

[xix] NY State Senate Bill S542A (nysenate.gov)
[xx] New Jersey Legislature - Bills (state.nj.us)
[xxi] Concrete Still a Barrier to Climate-Friendly Infrastructure Plan (bloombergtax.com); Bill Text - SB-596 Greenhouse gases: cement sector: net-zero emissions strategy. (ca.gov)

[xxii] Concrete Still a Barrier to Climate-Friendly Infrastructure Plan (bloomberglaw.com)

[xxiii] Reducing Embodied Carbon in Buildings - RMI
[xxiv] Final 1119 Procurement.pdf (mit.edu)
[xxv] Brookline-Concrete-Sidewalk-Specifications-PDF (brooklinema.gov)

[xxvi] PW20-18---Larz-Anderson-Lagoon-Structures_Specifications (brooklinema.gov)
[xxvii] Greenhouse Gas Equivalencies Calculator | US EPA