FAILING U.S. CONCRETE MAY COST TRILLIONS

One trillion dollars. That's what President Donald Trump proposes for rebuilding our nation's crumbling infrastructure, much of it concrete. The American Society of Civil Engineers suggests $4.6 trillion is a better number, based on its benchmark report from last week. That profession has spent more time studying concrete than any other.

Steel-reinforced concrete is an essential structural material in U.S. cities. It's the main mass of our pavements, bridges, airports, subways, dams, ports, canals, sidewalks, sewers and parking garages. To talk infrastructure at the federal level is to talk concrete.

Trump's xenophobic wall between the U.S. and Mexico will be made of pre-cast concrete. Its announcement boosted share prices for CEMEX, a multinational concrete manufacturer based in Mexico. Will they be allowed to profit from walling themselves out?

Reading the American Society of Civil Engineers report prompted me to reread an interesting technical article published in September 2014 by two civil engineers from Boston University. Their case-study, published in the journal Urban Climate, concluded that the disintegration of steel-reinforced concrete in their city was taking place much faster than expected. For all practical purposes, Boston's bones are experiencing accelerated urban osteoporosis. The culprits they name are the enhanced carbonization and chlorination of the atmosphere.

Rereading this made me wonder what the true price tag will be for routine repair and replacement of concrete across the United States. Will it rise in a geometric progression from $1 trillion to $4 trillion to $16 trillion? If so, the time has come to slash the U.S. military budget, arm our civil engineers and guard against collapse from within.

And now a concrete primer. Plants are made of carbon. They get their carbon from the air. Burning fossil fuel puts that carbon back into the air faster than it comes back out. This causes the amount of carbon in the air to increase. This puts more carbonic acid in the rain, mist and ocean surface. Seashells and corals are made of carbon. We burn them to make cement, releasing carbon. That carbon makes more acid. That cement, mixed with aggregate, makes concrete. That concrete is increasingly vulnerable to the increased acid.

Our reliance on fossil fuels for combustion (CO2) and their use to make cement (calcium carbonate) has increasingly carbonized the air from 280 to 406 parts per million. One impact is climatic through the greenhouse effect: A warmer atmosphere melts more ice, expands the ocean volume, increases the strength of coastal storms and raises sea level. In New England, it also makes the ambient air moister and increases cloudiness and rainfall. The other impact of carbonizing the atmosphere involves wet chemistry.

There are two important reactions. Most pervasive is the accelerated leaching of the cement. Warmer temperatures, elevated moisture and more pervasive carbonic acid in drops and droplets literally causes the calcium carbonate in cement to dissolve like a marble tombstone. The second reaction is chlorination. Chlorine comes from ocean mists and sea-spray, and from de-icing salts. Higher, warmer seas and stronger storms are sending greater concentrations of chlorine further inland. When concrete is wet with it, the chlorine diffuses inward.

The critical moment comes when the carbonization and chlorination reach the steel rebar that holds concrete together. The metal corrodes, the rust expands, the structure weakens, the concrete cracks, chunks spall and a city falls apart.
Much of our nation's concrete is a post World War II phenomenon. Like me, it came of age in the 1960s and 1970s. The civil engineers who supervised its use were well aware of the chemical and physical processes involved. What they didn't take into account was the higher reaction coefficients associated with an atmosphere richer in carbon everywhere, and richer in chlorine near the coasts.

Much of the new concrete is quite good, and will easily last half a century or more. The problem is with baby-boom-era concrete. Like us, it's getting older. Unlike us, its life expectancy is falling.