The minerals that attack your concrete driveway

Those hard concrete driveways! How nice they are when first laid. Then they crack, crumble, spall and need replacing. This is not only true of your driveway, but also of our whole concrete infrastructure ranging from stadiums to dams to interstates, which costs the U.S. an estimated $150 billion a year. What eats the concrete? It turns out that many of concrete's foes are minerals.

Concrete consists of cement paste (a complex mixture made mostly of calcium hydroxides and calcium aluminum silicates) and aggregate (sand and gravel). The process of making the cement begins with limestone and clay. These are mixed, heated, ground and treated with gypsum. Adding water to this starts a number of chemical reactions, forming calcium hydroxides (one of which is called portlandite), calcium aluminum silicates and calcium sulfates (such as ettringite). These reactions continue for days until the cement is finally set and hard. What minerals attack this formidable material?

Ice is an obvious villain. Ice is a perfectly good mineral – inorganic, naturally occurring and possessing a crystalline structure. When water freezes to ice, it expands by about 9%, exerting tremendous force on the sides of any cracks or pores into which it has seeped. As the cracks and pores enlarge, it is easier for more water to enter.

Salt is another enemy. As you spread salt on your drive way, or as salty residue drips off your car, the salt water soaks into the concrete. As the water evaporates, salt crystals grow, forcing apart cracks. Salt can have a more insidious effect, depending on what aggregate is in the concrete. If the aggregate contains poorly crystalline silica, in the form of opal or even chert, its reacts with sodium, converting the hard silica to a hydrated alkali gel. This decreases the strength of the concrete. Since the gel occupies more volume than the original chert or opal, it further cracks the concrete and helps more water enter. By the way, Scott Wolter describes some deposits of the solidified gel material in voids in concrete that show agate-like banding. This may help us to better understand the formation of agates.

Sulfur, which occurs in soils, seawater, and acidic rain, is another enemy. Portlandite, formed during the hardening of the cement, reacts with the sulfur-bearing water to make gypsum and more ettringite. Gypsum is soft and water soluble, degrading the concrete. Both gypsum and ettringite cause an increase in volume, cracking the concrete. The more cracks, the more water and sulfate and salt can enter. This cycle limits concrete's lifetime. Millions of research dollars are going into making concrete more

resistant to these attacks. The only way to avoid this completely is to build in where water, salt and ice don't occur. The nearest surface like that is on the moon.

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References:

Wenk, Hans-Rudolf and Andrei Bulakh 2004. *Minerals: Their Constitution and Origin.* Cambridge University Press.

Wolter, Scott, 1996, The Lake Superior Agate, third Edition, Burgess International Group Publishers.