After 2,000 years, a long-lost secret behind the creation of one of the world's most durable man-made creations ever—Roman concrete—has finally been discovered by an international team of scientists, and it may have a significant impact on how we build cities of the future.

As anyone who's ever visited Italy knows, the ancient Romans were master engineers. Their roads, aqueducts, and temples are still holding up remarkably well despite coming under siege over the centuries by waves of sacking marauders, mobs of tourists, and the occasional earthquake. One such structure that has fascinated geologists and engineers throughout the ages is the Roman harbor. Over the past decade, researchers from Italy and the U.S. have analyzed 11 harbors in the Mediterranean basin where, in many cases, 2,000-year-old (and sometimes older) breakwaters constructed out of Roman concrete stand perfectly intact despite constant pounding by the sea.

The most common blend of modern concrete, known as Portland cement, a formulation in use for nearly 200 years, can't come close to matching that track record, says Marie Jackson, a research engineer at the University of California at Berkeley who was part of the Roman concrete research team. "The maritime environment, in particular, is not good for Portland concrete. In seawater, it has a service life of less than 50 years. After that, it begins to erode," Jackson says.

The researchers now know why ancient Roman concrete is so superior. They extracted from the floor of Italy's Pozzuoili Bay, in the northern tip of the Bay of Naples, a sample of concrete breakwater that dates back to 37 B.C. and analyzed its mineral components at research labs in Europe and the U.S., including at Berkeley Lab's Advanced Light Source. The analysis, the scientists believe, reveals the lost recipe of Roman concrete, and it also points to how much more stable and less environmentally damaging it is than today's blend.

That's why the findings, which were published earlier this month in the Journal of the American Ceramic Society and American Mineralogist, are considered so important for today's industrial engineers and the future of the world's cities and ports. "The building industry has been searching for a way to make more durable concretes," Jackson points out.

Another remarkable quality of Roman concrete is that its production was exceptionally green,

a far cry from modern techniques. “It’s not that modern concrete isn’t good—it’s so good we use 19 billion tons of it a year,” says Paulo Monteiro, a research collaborator and professor of civil and environmental engineering at the University of California, Berkeley. “The problem is that manufacturing Portland cement accounts for 7 percent of the carbon dioxide that industry puts into the air.”

The secret to Roman concrete lies in its unique mineral formulation and production technique. As the researchers explain in a press release outlining their findings, “The Romans made concrete by mixing lime and volcanic rock. For underwater structures, lime and volcanic ash were mixed to form mortar, and this mortar and volcanic tuff were packed into wooden forms. The seawater instantly triggered a hot chemical reaction. The lime was hydrated—incorporating water molecules into its structure—and reacted with the ash to cement the whole mixture together.”

The Portland cement formula crucially lacks the lyme and volcanic ash mixture. As a result, it doesn’t bind quite as well when compared with the Roman concrete, researchers found. It is this inferior binding property that explains why structures made of Portland cement tend to weaken and crack after a few decades of use, Jackson says.

Adopting the materials (more volcanic ash) and production techniques of ancient Roman could revolutionize today’s building industry with a sturdier, less CO2-intensive concrete. “The question remains, can we translate the principles from ancient Rome to the production of modern concrete? I think that is what is so exciting about this new area of research,” Jackson says.

Of course, if you are no fan of concrete architecture, you’re out of luck. It could be with us for a few millenia more.

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