The secret of ancient Roman concrete

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Ancient Roman concrete has survived for millennia, but knowledge of the reasons for its long-lasting durability has remained a mystery to this day. A study published on January 6, 2023, in Science Advances, the journal of the American Association for the Advancement of Science (AAAS), claims that the reasons for this advantage have been identified.

The most impressive example of Roman concrete is the Pantheon, which the painter Michelangelo described as "angelic and not human design". It still looks strikingly modern today and remains the largest unreinforced concrete dome in the world, 19 centuries after its construction.

With only a few isolated exceptions, it was about 1,400 years after the fall of the Western Roman Empire before concrete was again used on a large scale. The invention of reinforced concrete gave the material a new life. It was first introduced in France in the middle of the 19th century.

Scientists have long wondered how the Romans achieved such a massive engineering feat. Researchers have found that Roman concrete has the ability to repair cracks created in it. These cracks allow moisture to penetrate, a fact that constitutes a mortal enemy of reinforced concrete. The collapse of the Ponte Morandi Bridge in Genoa, Italy, and balcony collapses in Cyprus and elsewhere, are examples of this weakness of modern concrete.

To study the durable building material, researchers took mortar samples from walls in the ancient city of Privernum, near Rome. The mortar contained small white chunks of calcium deposits called lime clasts. Previously, researchers thought the chunks meant the Romans didn't mix the concrete well enough. The new study revealed the origin of the deposits. Ancient engineers used the dry, most reactive form of limestone called quicklime, instead of or in addition to slaked lime, which is combined with water first. Mixing with quicklime would have set off chemical reactions, causing extreme temperatures (known as “hot mixing”) and creating the calcium deposits. The deposits also served the purpose of self-healing the cracks, the researchers found. As water seeps into cracks in the concrete, it dissolves the calcium deposits. The dissolved chemicals then recrystallize or react with other materials, filling the cracks and strengthening the structure. To test this, the team made concrete using a Roman recipe and a modern recipe. They then broke up the samples and let the water run through it for 30 days. Modern concrete still allowed water to pass through, which Roman concrete did not, suggesting that the cracks had been filled.

The new findings, the researchers hope, could lead to more durable modern concrete. Given that around 8% of global greenhouse gas emissions come from cement production, longer-life concrete could also reduce the industry's contribution to climate change.

The full study is at the following link, also available in PDF:

https://www.science.org/doi/10.1126/sciadv.add1602

Information about the Pantheon of Rome in Wikipedia:

https://en.wikipedia.org/wiki/Pantheon,_Rome


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