The Rock Solid History of Concrete
by: Jonathan Schifman Oct. 12, 2017

Roman Concrete

Let's get this out of the way right here: cement and concrete are not the same thing. Cement, a mixture of powdered limestone and clay, is an ingredient in concrete along with water, sand, and gravel. Yet, the story of concrete is so ancient that we don't even know when and where it begins. Emperors and kings became legends for erecting great concrete structures, some of which are still a mystery to engineers. Today, the world is literally filled with concrete, from roads and sidewalks to bridges and dams.

The ancient concrete used clay as a major component, and a volcanic ash, today called pozzolana, was also used. Pozzolana is derived from Pozzuoli, Italy, which is the site of Mount Vesuvius, whose eruption destroyed the Roman city of Pompeii in 79 AD. The same volcanic ash that covered that ancient city also helped the Romans create the first known concrete in the world—and the strongest concrete humanity has ever seen.

The connection between Rome and concrete is so strong that we even take the name "concrete" from them. It's derived from the Latin term *concretus*, meaning "to grow together," just the way the components of concrete mix to form a solid building block. But the Romans didn't refer to their concrete as "*concretus*." In fact, they called their concrete *caementis*, meaning "rocky stuff." *Caementis* is of course the word that gave us "cement."

What makes Roman concrete so impressive is its ability to endure substantial weathering, survive earthquakes, and withstand crashing waves in the sea. But to this day we still don't know all the secrets of the Roman recipe. The most comprehensive surviving text on Roman concrete is Vitruvius's *On Architecture*. However, that volume predates the construction of many of the Roman concrete structures, and is thus incomplete. When the Western Roman Empire officially fell in 476 AD, the recipe for concrete was lost to history.

Concrete Rediscovered

It took about a thousand years for concrete to make a comeback. Europe went through the Dark Ages, and ancient Roman texts were not rediscovered until the Renaissance. Renaissance engineers studied Vitruvius's *On Architecture*, but with no knowledge of the mysterious gray building material, scholars had a tough time deciphering Vitruvius' terminology. Only an Italian friar named Giovanni Giocondo was able to crack the code. Giocondo was trained in archaeology and architecture, and he noticed something impressive about *caementis*. Its resistance to weathering suggested it must be hydraulic, meaning it hardens under water. But bigger breakthroughs were on the horizon.

In the 16th century, trass—a volcanic ash similar to pozzolana—was discovered as a useful material for making tools in Andernach, Germany. A bricklayer tried using the ash in lime mortar, and learned that the resulting material was stronger and also water resistant. The result was a chain reaction that led to the creation of modern cement. In the 17th century, the Dutch began selling trass to France and Britain. The trass was used for buildings that required hydraulic properties. In constant conflict and competition, France and Britain began efforts to create their own hydraulic building materials.

England came out ahead as a result of John Smeaton, known as the father of civil engineering. And more than a thousand years after the fall of Rome and the loss of concrete's secrets, Smeaton rediscovered how to make cement. The English civil engineer experimented with known hydraulic materials. He rolled up balls of lime (cooked version of limestone) and trass and dropped them into boiling water. The lime on its own dissolved, but the lime that came into contact with trass endured. Smeaton then tested limestone from a town called Aberthaw, dropping it into water and a nitric acid solution used to separate minerals. The experiment revealed that about a tenth of the limestone from Aberthaw contained clay. Smeaton took note of the high strength of this limestone-clay conglomerate. Today we call the same material natural cement.

The Birth of Modern Concrete

In the mid-1800s, most industrialized countries were making Portland cement. Around this time, the United States, Britain, and France each had the same idea to increase concrete's tensile strength, or its ability to resist an exerted force. Concrete could be poured over iron bars to form reinforced concrete.

In the 1880s, a California-based engineer named Ernest Ransome noticed that reinforced concrete tended to crack, subsequently weakening significantly. He decided to experiment with the reinforcement bars, using 2-inch iron rods to see if they'd bond with the concrete. The experiment was a success. Ransome then tried twisting the iron bars in accordance with the concrete's desired shape. It worked like a charm. The engineer called his idea the Ransome system. Today we call it reinforcing bar, or rebar, and modern engineers typically use steel. In 1903, construction was completed on the world's first concrete skyscraper, the 16-story Ingalls Building in Cincinnati. Ransome himself was not involved in the skyscraper's construction, but it would not have been possible without his reinforcing bar method. Ever since Ransome developed the perfect rebar, concrete has been used to build all types of monumental buildings and infrastructure works. Some of the toughest buildings in the world rely on a concrete foundation.

And yet even now, in this 21st century concrete jungle, there may be ways to improve the famed gray building material. Rebar made the modern world possible. But in terms of longevity, reinforced concrete is no match for what the Romans used. Rebar oxidizes when the surrounding concrete cures. Over decades, it rusts. The rebar will expand enough to put cracks in the concrete. In general, modern concrete can last about a century without major repairs or replacement, according to Concrete Planet. The impressive tensile strength of many of our structures is only temporary, and maintaining them is costly.

Seawater is particularly harmful to rebar, as the salt will corrode the steel within just five decades. Water can seep in naturally as tiny holes and, eventually, small cracks form on a concrete structure. Freeze-and-thaw cycles leave cracks in concrete roads as well, and while spreading salt will deter ice formation, it harms the rebar just as seawater does.

A recent report suggests it's possible. We know the volcanic ash pozzolana was fundamental to the strength of ancient Roman concrete, though we still have not pieced together the full recipe. In July, researchers announced they would use similar volcanic ash off the coast of California in an attempt to solve the ancient mystery. The goal is to reverse-engineer the process that created the most durable concrete in history.

Roman concrete is not just waterproof—it actually strengthens when in contact with seawater. Microscopic crystals are thought to grow in the ancient concrete when submerged in water. Roman concrete has a weaker tensile strength than rebar concrete, as one might imagine, but its ability to stand up to erosion and weathering is unparalleled. A combination of Rome's secret concrete recipe and modern rebar engineering techniques could allow concrete to revolutionize infrastructure and architecture yet again.

http://www.popularmechanics.com/technology/infrastructure/a28502/rock-solid-history-of-concrete/