SELF-HEALING CONCRETE COULD CUT COSTS

The concrete dome of the Pantheon (top) has proved enduring but steel reinforcement (right) can lead to corrosion

John Osborne explores how new forms of self-healing concrete could considerably reduce the workload for future generations of engineers

Some buildings containing concrete that were erected about 2,000 years ago still survive. Dr Benjamin Stafford, a materials science specialist at Matmatch, an online search engine that allows engineers to compare the properties of different materials, explains that the "Romans were technically the first to use self-healing concrete, using tuff together with a form of lime mortar, containing volcanic ash, quicklime and water.

"The 'pozzonic' reaction between chemicals in the mixture and water (which enters through cracks) results in the growth of calcium aluminosilicate, filling the cracks. This is used, for example, in the Pantheon in Rome."

However, many modern engineers, because they have no alternative, still adopt the traditional approach, which is to repair damaged concrete. The concept of applying self-healing properties that can reduce maintenance cost and time in the future is still novel but has enormous potential.

According to Fieldlens, a US construction company, "Concrete starts to crumble when it comes face-to-face with water, wind, stress and pressure. The current method of dealing with structural instability is to replace or repair it. But what if all you had to do was add a little water?

"A new type of smart concrete contains dormant bacteria spores and calcium lactate in self-contained pods. When these pods come into contact with water they create limestone, filling up the cracks and reinforcing the concrete. Self-healing concrete is estimated to save up to 50% of concrete's lifetime cost by eliminating the need for repair."

Built to last

Dr Richard Barnes, who works for the Concrete Society, disagrees: "Concrete very rarely crumbles when it encounters water, wind or stress within its design capability (note the 2,000-year-old concrete roof of the Pantheon). However,

'Smart concrete contains bacteria spores and calcium lactate. When these contact water they create limestone, filling up the cracks'

steel reinforcement within reinforced concrete can corrode, an expansive reaction that can damage concrete."

He adds: "While research has been conducted on putting bacteria in concrete to help heal cracks, concrete already has the ability to autogenously heal fine cracks. Crystalline admixtures have been available for many years which can enhance this self-healing capability."

According to Isaac Premsingh, an analyst who works for consultancy Frost & Sullivan, he and his colleague Khadija Afia Allapitchai said in a webinar that: "Researchers at Delft University of Technology in the Netherlands have developed self-healing 'bio' concrete. The concrete is mixed with calcium lactate and bacteria, which can remain dormant for up to 200 years.

"When cracks form in the bio-concrete and water starts to seep through, the bacteria are activated. They consume the calcium lactate and start to produce limestone, a by-product that heals the cracks."

It is an interesting technology but usually construction materials can only be used in accordance with international standards.

Cost and safety factors

"Bio-based self-healing concrete is a very new material, and standards take time to develop," says Stafford.

Another big consideration is cost. "One potential downside of self-healing concrete," says Stafford, "is that adding bacteria and water-absorbent polymers may drive up the cost, making it unfeasible for projects where a high volume of materials are required.

"Engineers considering using self-healing concrete should assess its functionality and cost" in comparison with conventional concrete. "I imagine it will more likely be used in larger, more expensive projects, but only after its long-term safety has been thoroughly demonstrated."