

## **Bio-inspired Concrete Revitalization**

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The mission of US Defense Advanced Research Projects Agency (DARPA) is ‘to make pivotal investments in breakthrough technologies for national security’. The agency notes on its website: “The ultimate results have included not only game-changing military capabilities such as precision weapons and stealth technology, but also such icons of modern civilian society such as the Internet, automated voice recognition and language translation, and Global Positioning System receivers small enough to embed in myriad consumer devices.”<sup>1</sup>

### **The BRACE Program**

The internet and the use of GPS in consumer devices are ubiquitous. Thinking in the same vein as these successes, technologies involving artificial intelligence (AI) and drones may come to mind. To be sure, much effort is focused on these areas. One that may not come to mind is concrete repair.

Certainly, the use of concrete is ubiquitous. As are the problems associated with aging concrete infrastructure. DARPA is focusing on the possibility of revitalizing of Department of Defense (DoD) infrastructure based on new research suggesting that cross-disciplinary technologies can be used to impart aged concrete with self-healing capabilities

The new program with this focus is called Bio-inspired Restoration of Aged Concrete Edifices (BRACE). There is much backing by the current administration, which is strongly focused on infrastructure. BRACE program manager, Dr. Matthew J. Pava, referenced this priority as part of The American Jobs Plan 2021 and stated that “[w]hile BRACE is focused on DoD applications, our hope is that the technologies generated will have potential civilian benefits as well.”<sup>2</sup>

The program is a 4.5 year research effort that will focus on two Technical Areas (TAs) involving the development of ‘long-lasting systems for transport of healing substances throughout concrete, as well as practical tools for applying, maintaining, and predicting the long-term function and performance of these systems’:

TA1 will address the challenges of engineering bio-inspired approaches for establishing long-acting vascular structures deep within concrete both to repair cracks and to provide self-diagnostic signals that let the user know they are still functioning after years or decades.

TA2 will focus on the development of methods for applying and maintaining TA1 systems in concrete, rapid aging testbeds for vascularized concrete, and models that predict the system’s effectiveness in averting the need for future repairs.<sup>3</sup>

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<sup>1</sup> DARPA Website. About Section. Available at: <https://www.darpa.mil/about-us/about-darpa> Accessed on April 11, 2022.

<sup>2</sup> DARPA Gives New Life to Old Concrete Structures Through “Vascularization”. DARPA Website - News. March 3, 2022. Available at: <https://www.darpa.mil/news-events/2022-03-17> Accessed on April 11, 2022.

<sup>3</sup> Ibid.

## Implications

In its press release about the BRACE Program, DARPA referenced a 2014 Engineering Failure Analysis article indicating that “[t]oday, second only to water, concrete is the most consumed material, with three tonnes per year used for every person in the world. Twice as much concrete is used in construction as all other building materials combined.”<sup>4</sup>

If successful, the implications for the resulting technologies would be widespread. Use of the term “vascularization” is eye-catching. At a minimum, it would seem that the program expects to find new and practical ways to nurture concrete structure – preventing new damage, focusing repairs and shortening repair time, with the potential for significant maintenance cost savings and extended service life for concrete infrastructure.

One of The Guardian’s ‘Best of 2019’ articles is entitled ‘Concrete: the most destructive material on Earth’. They note that by one calculation, we may have already passed the point where concrete outweighs the combined carbon mass of every tree, bush and shrub on the planet.<sup>5</sup> An interesting read. In short, concrete has and continues to have an enormous carbon footprint.

Two very key global issues right now are infrastructure and the environment. DARPA is now on a path to find solutions to one of the key elements impacting these issues.

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<sup>4</sup> Gagg, Colin R. Cement and concrete as an engineering material: An historic appraisal and case study analysis. Engineering Failure Analysis. May, 2014. Available at: <https://www.sciencedirect.com/science/article/abs/pii/S1350630714000387#:~:text=Abstract,all%20other%20building%20materials%20combined> Accessed on April 11, 2022.

<sup>5</sup> Watts, Jonathan. Concrete: the most destructive material on Earth. The Guardian. February 24, 2019. Available at: <https://www.theguardian.com/cities/2019/feb/25/concrete-the-most-destructive-material-on-earth> Accessed on April 11, 2022.