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New 3D concrete printing method captures carbon dioxide

A new pathway to reduce the environmental impact of the construction industry.

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Sample of a conrete wall constructed using the newly developed 3D concrete printing method. Credit: NTU Singapore

Researchers at Nanyang Technological University in Singapore (NTU Singapore) have created a new 3D concrete printing technique that captures carbon, unveiling a novel approach to lessen the construction industry's environmental impact.

This groundbreaking technique seeks to greatly diminish the carbon footprint of cement—a substance that contributes to 1.6 billion metric tonnes of carbon dioxide (CO_2), or roughly eight percent of worldwide CO_2 emissions—by using less material, cutting down construction time, and lowering labor needs.

The new 3D concrete printing process incorporates steam and CO_2, which are captured as by-products from industrial activities, directly into the mixing concrete. This not only stores CO_2 in the concrete structure but also minimizes material usage shortens construction time and reduces labor requirements. Studies indicate that this method enhances the mechanical properties of the concrete, providing greater strength than traditional 3D-printed concrete.

"The building and construction sector causes a significant portion of global greenhouse gas emissions," said Professor Tan Ming Jen, principal investigator of the study. *"Our newly developed 3D concrete printing system offers a carbon-reducing alternative by not only improving the mechanical properties of concrete but also contributing to reducing the sector's environmental impact. It demonstrates the possibility of using CO_2 produced by power plants or other industries for 3D concrete printing. Since traditional cement emits a lot of carbon, our method offers a way to plough back CO_2 through 3D concrete printing."*

The research team believes their innovation represents a promising contribution towards achieving global sustainable development goals and reducing the industry's reliance on conventional energy-intensive processes like reinforced concrete construction.

The new development builds on previous 3D printing for construction research by Prof Tan and his team at NTU's SC3DP, as well as international collaborators.

To create their 3D concrete printing system, the research team linked the 3D printer to CO_2 pumps and a nozzle that emits steam. When activated, this system injects CO_2 and steam into the concrete mixture during the printing process. CO_2 interacts with the concrete's components, converting into a solid state that remains contained within the material (sequestered and stored).

At the same time, steam improves the absorption of CO_2 into the 3D printed structure, enhancing its properties. In lab tests, researchers found the printed concrete structure showed a 50 per cent improvement in printability, meaning it can be shaped and printed more efficiently. The structure also displayed better strength and durability.

Additionally, the structure demonstrated improved strength and durability, being up to 36.8 percent stronger in compression (the amount of weight it can support) and up to 45.3 percent stronger in bending (how much it can flex before breaking) compared to standard 3D printed concrete. Notably, the method is also greener, absorbing and trapping 38 per cent more carbon dioxide compared to traditional 3D printing methods.

"We are at a critical time where the world is accelerating efforts to meet climate change targets. We believe our technology could contribute to making the construction industry more sustainable," said Lim Sean Gip, PhD candidate from NTU School of MAE.

Co-author Dr Daniel Tay, Research Fellow from NTU School of MAE, said, "Our proposed system shows how capturing carbon dioxide and using it in 3D concrete printing could lead to stronger, more eco-friendly buildings, advancing construction technology."

A joint US patent application has been submitted for the innovation by NTU and its partners. In their upcoming research, the team aims to enhance the 3D printing method to increase efficiency and may explore the use of waste gases in place of pure carbon dioxide.