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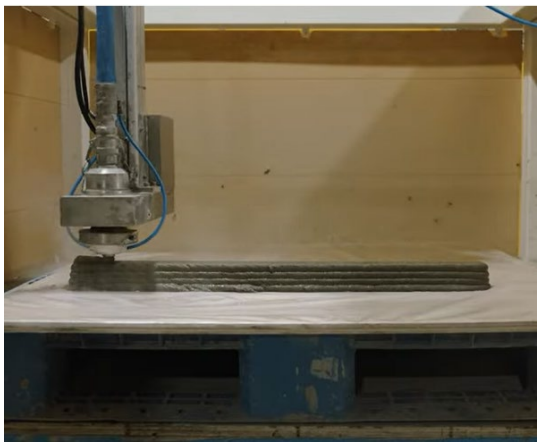
Singapore: NTU's Sustainable 3D Concrete Printing Tech

Alita Sharon | December 18, 2024

Scientists from Nanyang Technological University, Singapore (NTU Singapore) have developed a revolutionary 3D concrete printing method that captures and stores carbon dioxide (CO_2), offering a sustainable solution to one of the construction industry's biggest environmental challenges. This innovation significantly reduces cement's carbon footprint while enhancing the mechanical properties of concrete.



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Cement production is responsible for approximately 8% of global CO_2 emissions, contributing 1.6 billion metric tonnes of CO_2 annually. Traditional cement-based construction methods rely

on energy-intensive processes and emit substantial greenhouse gases. To address this, NTU researchers have integrated carbon capture technology with 3D concrete printing, creating an eco-friendly and efficient alternative.

The newly developed method involves injecting CO_2, captured as a by-product of industrial processes, and steam into the concrete mix during the printing process. The CO_2 reacts with components in the concrete and mineralises into a solid form, ensuring it is permanently stored within the material. Steam enhances CO_2 absorption, improving the overall performance of the printed structure.

In laboratory tests, the NTU team demonstrated significant improvements over conventional 3D-printed concrete. The new method showed a 50% increase in printability, allowing structures to be shaped more efficiently and with greater precision. Mechanical strength also improved substantially, with a 36.8% boost in compressive strength—how much weight the concrete can bear – and a 45.3% increase in bending strength, or the material's ability to flex before breaking.

Moreover, the method is more sustainable, absorbing 38% more CO_2 compared to traditional 3D concrete printing methods. This dual benefit – capturing carbon while producing stronger materials – positions the technology as a game-changer for the construction sector.

Professor Tan Ming Jen, the study's principal investigator from NTU's School of Mechanical and Aerospace Engineering (MAE) and Singapore Centre for 3D Printing (SC3DP), emphasised its significance: "The building and construction sector contributes significantly to global greenhouse gas emissions. Our system not only improves concrete's mechanical properties but also mitigates the sector's environmental impact by repurposing CO_2 from industrial emissions."

The research reflects NTU's continued efforts to advance sustainable construction technologies. By leveraging CO_2 emissions from industrial sources, the innovation aligns with global initiatives to reduce carbon emissions and achieve sustainable development goals.

First Author Lim Sean Gip, a PhD candidate at NTU's School of MAE, highlighted the urgency of such technologies, "At a time when climate change efforts are accelerating worldwide, our carbon-capturing technology offers a solution for a more sustainable construction industry."

Dr Daniel Tay, Research Fellow and Co-author, added: "Our system demonstrates how integrating carbon capture with 3D concrete printing can create stronger, more durable structures while reducing the industry's carbon footprint."

The team has filed a US patent for the technology, marking its potential for commercialisation. Moving forward, the researchers aim to optimise the process to enhance efficiency and explore the use of waste gases, such as industrial flue gases, as a CO_2 source. These advancements could further reduce costs and environmental impact, paving the way for widespread adoption.

This breakthrough builds on NTU's extensive research in 3D concrete printing and highlights the transformative potential of combining carbon capture with innovative construction technologies. By addressing both environmental and structural challenges, the team's work offers a practical pathway for a greener and more sustainable built environment.

NTU's carbon-capturing 3D printing method marks a critical step forward in reshaping how concrete is produced and used, contributing to stronger, eco-friendly buildings that meet the demands of a rapidly changing world.

NTU scientists are also exploring ways to improve carbon capture from waste incineration. While calcium looping captures CO2, it's costly and energy-intensive. Their model shows that using waste-derived fuels and calcium sources can reduce costs, while carbon credits and emissions policies make the technology more economically viable.