Printing our way out of the Netherlands housing crisis: 'It is desperately needed'

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Credit: Eindhoven University of Technology

Eindhoven leads the way: for the first time, Dutch residents are moving into a 3D-printed concrete home. Professor Theo Salet of Eindhoven University of Technology (TU/e) is the driving force behind Project

Milestone, which is more relevant than ever before due to the housing crisis. An interview with an impassioned man: "We are facing an unprecedented challenge."

It sometimes seems as if freshly printed concrete has a will of its own. The mixture constantly reacts to changes in temperature during curing and tends to collapse like a plum pudding when there is insufficient stiffness. To complicate matters further, the printing process needs to account for inclined walls and the changing weight of the structure.

With a little imagination, you can compare concrete printing to walking on a very thin tightrope: you must not print too quickly (the structure then becomes unstable) but also not too slowly (the printed layers will no longer adhere). It's no small feat.

Customization on a large scale

Under these difficult conditions, Theo Salet and his team have spent years looking for ways to develop safe, rigid structures through which unique homes with a distinctive character can roll out of the concrete printer. Customization on a large scale instead of standardization.

The project caused him some headaches. Salet is a professor and dean of the Department of the Built Environment at TU/e and the driving force behind the Project Milestone, a collaboration between TU/e, Eindhoven municipality, construction company Van Wijnen, building materials manufacturer Saint Gobain Weber Beamix, engineering firm Witteveen + Bos and housing investor Vesteda.

For years, Salet worked with Ph.D. students Rob Wolfs and Zeeshan Ahmend and various master's students and third parties on the construction of the first completely 3D-printed house that meets all building requirements. He regularly had to swallow disappointments,

such as during the search for the right combination of concrete and insulation material for the sandwich walls, but these were just as often followed by the realization that his team was making progress.

"The fact that we've already come this far makes me a proud man," Salet says as he strolls the grounds near the 3D-printed home in Eindhoven's Meerhoven district this morning. He is also proud of how the knowledge developed has found its way to industry so quickly. Printing a wall is one thing, but producing a complete house is a different kettle of fish. This can only be done with the right industrial partners, emphasizes the professor.

"What's nice is that there's still so much to be gained just by learning from this experience," he explains as his eye travels across the structure. The shape of the house is inspired by that of a boulder, a polished version of the housing that used to be featured in the Flintstones cartoon, with a sleek and modern interior.

First occupant of 3D concrete printed house in Eindhoven receives the key

The first tenant of the first Dutch home made of 3D-printed concrete will receive the key today, April 30. The house in Eindhoven, the first of five from Project Milestone, fully complies with all strict Dutch building requirements.

The house is a detached single-story home with 94 square meters of net floor area, a generous living room and two bedrooms. It is located in the Eindhoven neighborhood of Bosrijk. The home consists of 24 printed concrete elements, which were printed layer by layer at the print factory in Eindhoven. The elements were transported by trucks to the building site where they were placed on a foundation.

Real necessity

There's a reason Salet is putting his heart and soul into this project. The urgency is profound, he stresses several times this morning. "This is not about the ambition of some scientist, it's about the rock-hard necessity of making major changes to the way we build," Salet says, referring to the ever-expanding housing shortage and the pressing climate issue, among other things. "Understand that we need to build in the Netherlands alone a million homes in 10 years and make 7.5 million homes drastically more sustainable in 30 years. In addition, infrastructure from the 1960s and 1970s is heading towards the end of its design life. We are facing an unprecedented challenge."

Unprecedented challenges call for rigorous measures. In fact, the professor argues, you need to turn the entire chain upside down. The construction sector must be more focused on the demands of society and, at the same time, more productive and sustainable. People, profit, planet, to put it briefly. According to Salet, this is the path along which we must pursue the transition. Close collaboration between academia, industry and the government is of great importance—the triple helix model. Salet: "Make that the quadruple helix model. You have to involve the public as well. Isn't it crazy that residents barely have a say in their own built environment?"

In order to break the chain, the need must first be felt by all parties involved. Salet: "Take the government, which must realize that the housing shortage is an issue for which it does not have an answer, simply because no one has the answer. The academic world can stimulate innovation, but there has to be a concrete question on the table. Industry must also be given the opportunity to make the transition to high-quality manufacturing. The municipality of Eindhoven understood this in the Milestone project and dared to take on this unique challenge."

Indeed, the government can create the conditions that foster partnerships which accelerate innovation. "Create pilot projects to experiment with and then scale them up. In tenders, look not only at price but also whether the construction project scores highly in areas such as circularity or innovation in the construction and manufacturing industries. If the urgency is felt, parties will seek each other out." The professor points to Eindhoven-based VDL, for example, which will be working with Van Wijnen in Heerenveen.

Industrial customization

In the media, Salet regularly reads that standardization should become the new norm. Modular construction is gathering more and more attention, but he dismisses this idea. "We'll then start delivering mass production and, in a while, the same houses will line every street. That would be extremely monotonous; no one is waiting for that and it isn't necessary either. You have to digitize the entire process from design to construction. A robot doesn't care what shape it has to print, so you then get industrial customization with variation. Let's make that step in one go, as challenging as it may be."

If the construction industry can make a dramatic shift, as Salet says it can, the benefits of industrial customization will be huge. Productivity will skyrocket. Additionally, you will need less high-quality craftsmanship in a market with a desperate shortage of skilled workers. The heavy work will disappear. This will make more room for women in the sector while the health of employees will also improve; a bad back or worn knees will be a thing of the past.

The biggest gains, however, will be in the areas of sustainability and circularity. "The amount of material we currently use in construction is unprecedented. We need to cut down." Concrete, for example, is one of the largest emitters of CO_2 worldwide. By both adjusting the

composition and reducing the user quantity, giant leaps can be made. The reuse of materials and elements of a 3D-printed house should also become possible in the future. "We're currently working hard on that." Salet is hopeful and sets his sights high: "It's absolutely possible to use 50% fewer raw materials and increase construction speed by 35%."

Second floor

For this reason, the professor would prefer to continue developing the printing method as quickly as possible. The momentum is there. In addition to the first home, he wants to realize a second house in the near future which will be a step further along than its predecessor: a second floor. In total, Project Milestone covers five concrete-printed homes. Salet: "I now want to work from industrial product to design instead of the other way around. For the first house we first created a design without an estimate of whether the printer can produce certain shapes, so we tried to force the printer. The question should be: which products can the printer handle? From there, we can create a variety of designs. Artificial intelligence is going to help with this and will become necessary in order to keep the quality of the printed work consistent, especially if we're going to print a home on site."

Meanwhile, research into 3D concrete printing is gaining popularity around the world. "We've set the tone," says Salet. "In terms of technological development, we're at the forefront. Printing layers and building a wall can be done by others. But producing an entire house that meets the strict requirements of a building permit and is also inhabited, that's truly unique. We can be very proud of that. We're increasingly understanding the will of printed concrete."

Provided by Eindhoven University of Technology