

# NTU's 3D-printing robot makes bathrooms nearly twice as fast and cheap



The technology could potentially help firms build prefabricated bathroom units that are 30 per cent lighter than current models using one-third less time. ST PHOTO: KEVIN LIM

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SINGAPORE - Bathrooms for housing units could one day be built more quickly and cheaply using 3D printing.

Researchers from Nanyang Technological University (NTU) said they have created the world's first 3D-printed unfurnished bathrooms.

A large 3D-printing robot took nine hours to print the 1.6m by 1.5m by 2.8m bathroom, and another 12 hours to print a second bathroom more than twice that size.

The process took about half the time now needed to construct a prefabricated bathroom using concrete casting.

Five more days were needed to furnish them with a sink, mirror, shower, toilet, ceramic tiled walls and flooring, complete with concealed drains and piping - making them ready to be installed in housing units.

Typically, prefabricated bathrooms cost between \$6,000 and \$7,000 to make but the NTU researchers said a 3D-printed one could cost around half as much.

Since 2014, all new non-landed residential Government Land Sale sites, such as HDB flats and some condominiums, have used prefabricated bathrooms that are constructed in factories before being assembled on-site to save time.



The NTU team said their process would reduce man hours further.

Speaking at the unveiling of the small bathroom at the NTU School of Mechanical and Aerospace Engineering on Wednesday (May 22), Associate Professor Tan Ming Jen said 3D-printing a bathroom unit could also lower transport costs, carbon emissions and wastage.

Said Prof Tan: "By being able to print on-demand, companies can save their inventory costs and manpower costs as they don't have to hold as much stock and their workers can be redeployed to do higher-level tasks. This approach also improves workplace safety since robots are doing the construction of the bathroom unit."

The innovation was developed by a multi-disciplinary research team from NTU's Singapore Centre for 3D Printing, in partnership with Sembcorp Design and Construction, and Sembcorp Architects & Engineers.

Building a bathroom in a housing unit is the most complex, manpower-heavy and time-consuming process because tiling, waterproofing, plumbing, electrical wiring and fixtures are needed. Other rooms mainly require wiring.

Scientists from mechanical, civil and material engineering, architecture and robotics developed four special concrete mixtures suitable for 3D-printing over three years, starting in 2015.

A third of the mixture for the small bathroom was made using leftover ash from Sembcorp's coal power plant, and the rest of the materials included sand and clay.

The mix is fluid enough to flow through hoses and out of the robot's print nozzle. It takes a couple of minutes to set so that the next layer can be printed over it.

To save material and make the bathroom 30 per cent lighter than a conventional prefabricated bathroom unit, the walls were printed in a W-lattice shape, which also lent additional strength to the structure. Pipes and wires can be installed in the empty spaces within the structure, instead of by drilling holes into walls.

The bathrooms were 3D-printed last September.

Mr Lie Liong Tjen, Sembcorp Design and Construction, and Sembcorp Architects & Engineers' team leader, said 3D printing would also allow buyers to customise their bathroom design.

Said Mr Lie: "Conventional construction of prefabricated bathrooms with concrete or lightweight wall panels always limit the possibilities of design. 3D printing can build curvilinear profiles (along with) rectilinear forms."

The larger bathroom has passed stringent tests to meet the required strength and robustness standards of the Building and Construction Authority. It is currently undergoing fire resistance tests, which will be completed in three months.

To eventually install 3D-printed bathrooms in houses, the team is hoping to commercialise the technology through licensing or by launching a spin-off company.

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