World's first 3D-printed steel footbridge unveiled by robot

July 15 2021, by Caroline Brogan

Credit: Imperial College London

The bridge, which is over four years in the making and is led by Dutch company MX3D, will be a "living laboratory" in Amsterdam's city center. Using its vast network of installed sensors, Imperial College

London researchers will measure, monitor and analyze the performance of the novel 12-meter-long structure as it handles pedestrian traffic.

The data collected will enable researchers and engineers to measure the bridge's 'health' in real time, monitor how it changes over its lifespan and understand how the public interacts with 3D-printed infrastructure.

The data from the sensors will be put into a 'digital twin' of the bridge—a computerized version which will imitate the physical bridge with growing accuracy in real time as sensor data come in. The performance and behavior of the physical bridge will be tested against the twin, which will help answer questions about the long-term behavior of 3D-printed steel, as well as its use in real world settings and in future novel construction projects.

To get from the conceptual stage to the installed footbridge, the Steel Structures group at Imperial conducted the underpinning research and validation, including testing destructive forces on printed elements, advanced digital twin computer simulations, non-destructive real world testing on the footbridge and the development of an advanced sensor network to monitor the bridge's behavior over its life.

Imperial co-contributor Professor Leroy Gardner of the Department of Civil and Environmental Engineering said: "A 3D-printed metal structure large and strong enough to handle pedestrian traffic has never been constructed before. We have tested and simulated the structure and its components throughout the printing process and upon its completion, and it's fantastic to see it finally open to the public."

Imperial co-contributor Dr. Craig Buchanan, also of the Department of Civil and Environmental Engineering, said: "We look forward to continuing this work as the project transitions from underpinning research to investigating the long-term behavior of metal printed

structures. Research into this new technology for the construction industry has huge potential for the future, in terms of aesthetics and highly optimized and efficient design, with reduced material usage. It has been fascinating and we are delighted that the structure is now ready to be used."

The testing work was led by Professor Gardner and Dr. Buchanan, supported by a team of undergraduate and postgraduate students, Ph.D. candidates, post-doctoral researchers and laboratory technicians. The team's work was predominantly funded by The Alan Turing Institute, with additional funding from the Engineering and Physical Sciences Research Council, part of UK Research and Innovation.

The bridge was installed over the Oudezijds Achterburgwal canal in Amsterdam's Red Light District and is being unveiled by a robot on July 15, 2021.

"Tremendous opportunities'

In the absence of structural design provisions for 3D-printed steel, physical testing and computer simulation is important for ensuring the safety of new 3D-printed structures. The Steel Structures group therefore undertook an ambitious research program using small-scale destructive material and cross-section testing, computer modeling and large-scale non-destructive real world testing on the footbridge.

Professor Gardner said: "3D printing presents tremendous opportunities to the construction industry, enabling far greater freedom in terms of material properties and shapes. This freedom also brings a range of challenges and will require structural engineers to think in new ways."

Dr. Buchanan said: "For over four years we have been working from the micrometer scale, studying the printed microstructure up to the meter

scale, with load testing on the completed bridge. This challenging work has been carried out in our testing laboratories at Imperial, and during the construction process on site in Amsterdam and Enschede, the Netherlands, on the actual printed bridge."

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The Imperial researchers are part of a wider team of structural engineers, mathematicians, computer scientists and statisticians working on The Alan Turing Institute-Lloyd's Register Foundation program in data-centric engineering. The program is led by Professor Mark Girolami at The Alan Turing Institute.

Professor Girolami said: "3D printing is poised to become a major

technology in engineering, and we need to develop appropriate approaches for testing and monitoring to realize its full potential. When we couple 3D printing with digital twin technology, we can then accelerate the infrastructure design process, ensuring that we design optimal and efficient structures with respect to environmental impact, architectural freedom and manufacturing costs."

The data captured from the bridge will be made available to other researchers worldwide who want to work with the Turing researchers in analyzing the data.

Now the bridge is unveiled, the researchers will begin collecting data in real time to monitor how it is behaving.

More information: Leroy Gardner et al, Testing and initial verification of the world's first metal 3D printed bridge, *Journal of Constructional Steel Research* (2020). DOI: 10.1016/j.jcsr.2020.106233

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Provided by Imperial College London