Structural health of world's first 3D printed steel bridge monitored by sensors and 'digital twin' technologies

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During the opening speech of Her Majesty Queen Máxima of the Netherlands (pictured centre, in orange). Credit: MX3D / Jande Groen

The world's first 3D printed steel bridge has been installed and unveiled in Amsterdam—with the potential to revolutionize how urban infrastructure is designed, built and maintained. Project lead Professor Mark Girolami led the structural integrity testing, as well as the design and installation of the bridge's sensor network. The team from the

Department of Engineering and The Alan Turing Institute are currently working on developing and deploying a 'digital twin' of the bridge.

The futuristic multi award-winning bridge, designed by Joris Laarman Lab, with Arup as lead engineer, has been placed over one of the oldest canals in Amsterdam's city center, the Oudezijds Achterburgwal canal. The bridge was officially opened on July 15 by Her Majesty Queen Máxima of the Netherlands.

Printed by Dutch technology MX3D using robotic arms, the 12 meter-long bridge is also equipped with an innovative sensor network, linked to a mathematical computer model forming a 'digital twin' of the physical bridge and its digital representation. The 'digital twin' monitors the bridge performance in real-time. The 'smart' bridge, in effect, serves as a living laboratory, with pedestrians, cyclists and runners generating data every time they cross the bridge. This data will help to monitor the bridge's structure and provide information about how it is being used.

More than 100 sensors attached to the bridge will monitor strain, movement, vibrations and weather conditions as people cross it. The data collected will be sent to a 'digital twin' of the bridge, which will help engineers assess how the bridge is faring, alerting them if problems occur and when maintenance might be required. The data will also provide input and lessons learned for future builds, helping designers understand how 3D-printed steel could be used in more complex projects. Statistical methodology will be utilized to understand more about the material itself and machine learning will be used to spot trends in the data pointing to potential changes, issues of maintenance or necessary modifications.

The sensor network was designed and installed by a team from the Turing Data-Centric Engineering (DCE) program that comprised of structural engineers, mathematicians, computer scientists and

statisticians, including researchers from the Cambridge Center for Smart Infrastructure and Construction (CSIC).

Dr. Mohammed Elshafie, CSIC Co-Investigator, has been collaborating with the DCE and MX3D to measure, monitor and analyze the performance of the bridge. The overall project was led by Professor Girolami, Sir Kirby Laing Professor of Civil Engineering, Royal Academy of Engineering Research Chair at the University of Cambridge, Academic Lead for CSIC and Program Director for Data-Centric Engineering at The Alan Turing Institute.

During the opening of the bridge by Her Majesty Queen Máxima of the Netherlands. Credit: MX3D / Adriaande Groot

"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," said Professor Girolami. "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."

3D printed steel is a new material, which may have the power to radically change conventional construction and overhaul the building industry. Load testing and materials testing conducted by the Turing DCE team, proved that the bridge is able to hold at least a 19.5 ton load, well above its ultimate design load.

Provided by University of Cambridge

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