2020 Digital Concrete

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

3D-Printed Concrete Bridge Designed by Topology Optimization

Gieljan Vantyghem, Wouter De Corte, Ticho Ooms, Emad Shakour & Oded Amir
GHENT UNIVERSITY | TECHNION - ISRAEL INSTITUTE OF TECHNOLOGY.
Gieljan.Vantyghem@UGent.be

SCAN ME

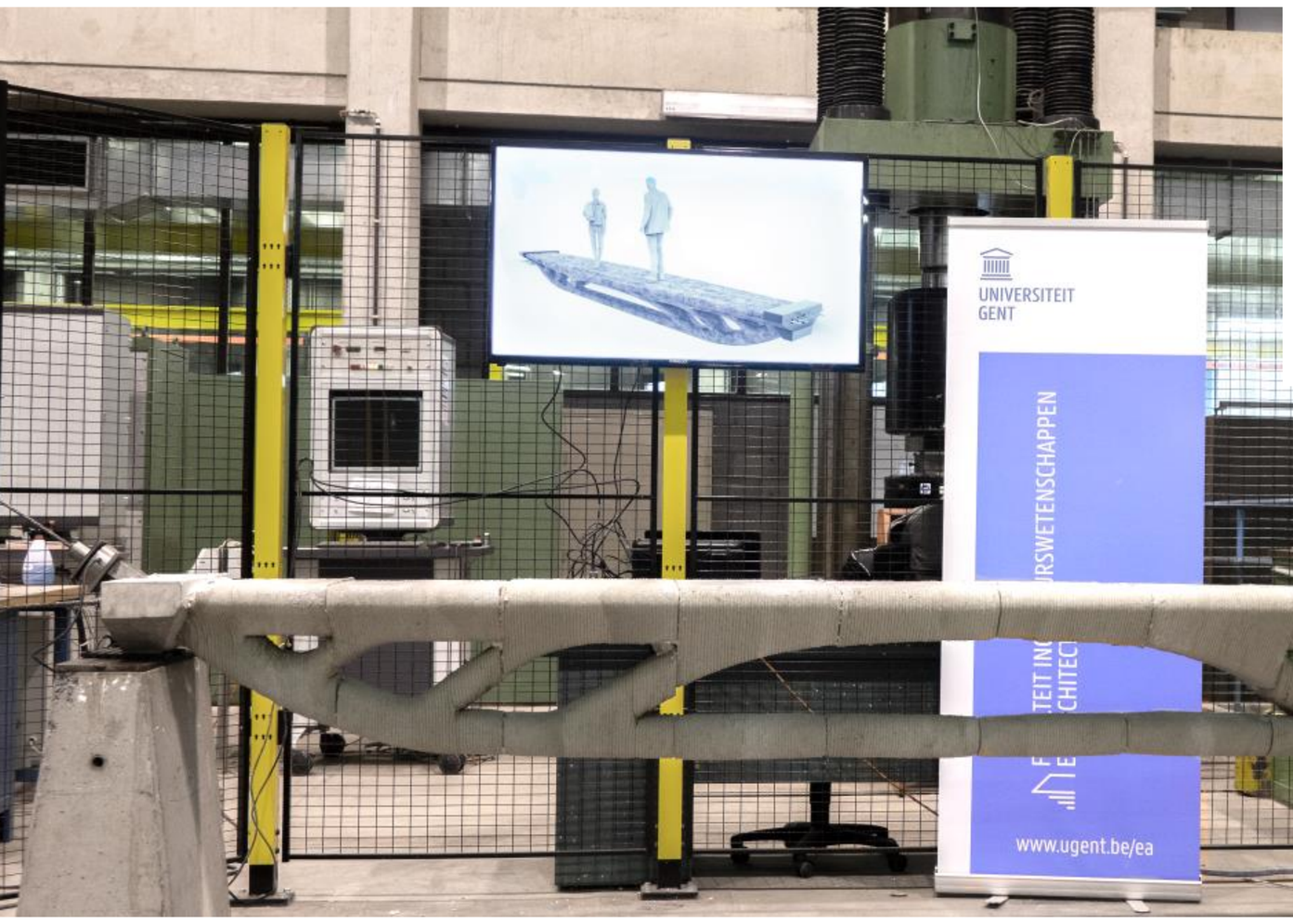
[1] G. VANTYGHEM, W. DE CORTE, E. SHAKOUR, O. AMIR, 3D PRINTING OF A POST-TENSIONED CONCRETE GIRDER DESIGNED BY TOPOLOGY OPTIMIZATION, AUTOMATION IN CONSTRUCTION (2020)

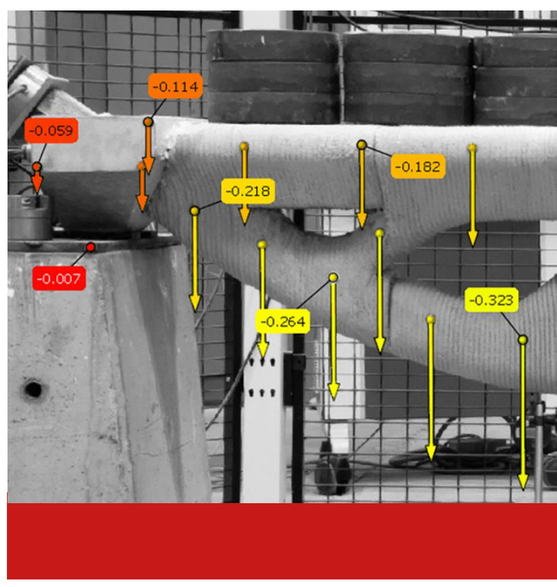
SHAPE OPTIMIZATION

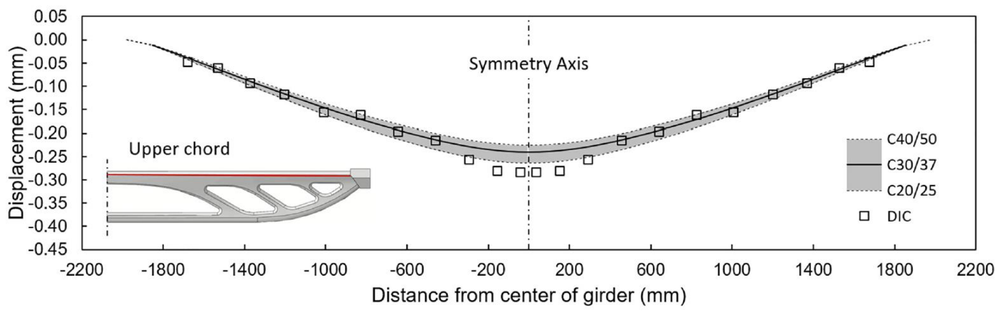
This project, thoroughly discussed in [1], presents the development of a post-tensioned digitally-fabricated concrete girder (4 m span) that was constructed at Ghent University, and resembles a lab-scale footbridge. The 2D shape of this girder was optimized using topology optimization techniques developed at Technion - Israel Institute of Technology. For this girder design, not only the concrete distribution was optimized using general topology optimization, but also the optimal shape of the post-tension cable was determined. The optimization algorithm seeks a design that minimizes the displacements at the top surface of the beam, due to the combined action of the external loads and the post-tensioning tendon.

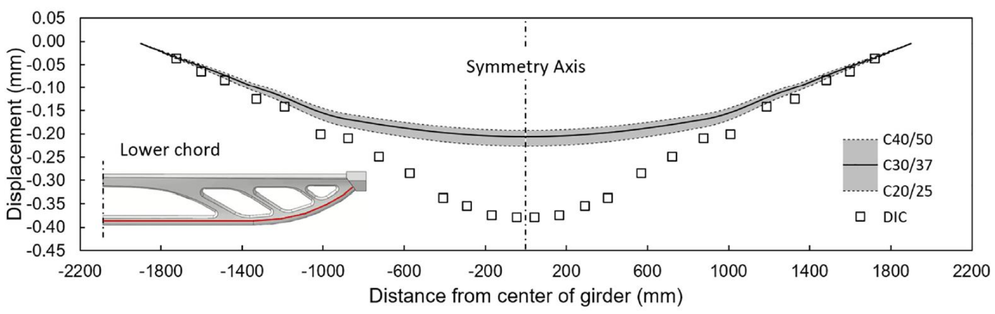
DESIGN VALIDATION

As the implementation of the optimization procedure was so far available in 2D only, some design post-processing was necessary, and a 3D finite element analysis was performed. The production of the 3DCP elements was realized in collaboration with Vertico, and the different parts were assembled at Magnel-Vandepitte Laboratory for concrete research. Finally, the girder's structural performance was experimentally verified using digital image correlation and its deflection was compared with the numerical results (see bottom left figure) In the referenced paper, also a comparison is made with a traditional T-section girder with the same total deflection, claiming material savings of roughly 20%!









CONCLUSION

In the end, this project showcases that a combined approach of design optimization and digital manufacturing is key to unlocking material savings in construction, reducing CO2 emissions while simultaneously increasing customization of products.

YouTube

SCAN ME

GHENT UNIVERSITY

Technion Israel Institute of Technology

VERTICO XL 3D Printing