Challenging the construction, logistics, waste and economy of concrete formwork

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TU Delft – Faculty of Civil Engineering and Geosciences

HiLo Nest concrete shell roof| Block Research Group (photo: Juney Lee)

Construction of DFAB House | Gramazio Kohler Research (photo: GKR)

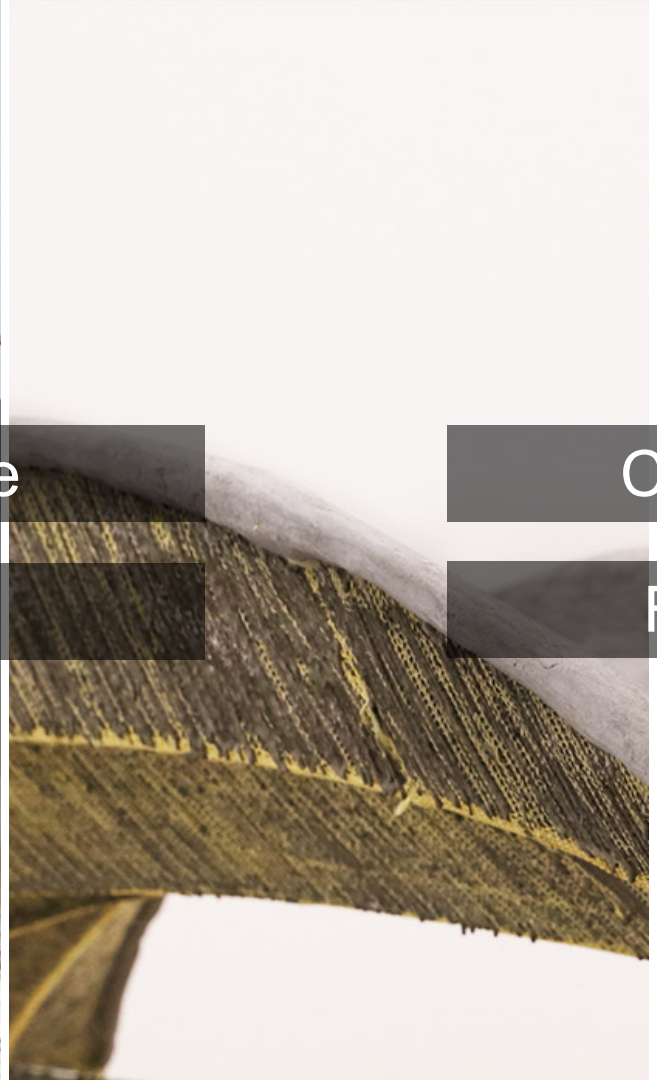
Architecture

Structure

Computation

Fabrication

Armadillo Vault | BRG Photo: Iwan Baan



KnitCandela | BRG Photo: Angelica Ibarra


Environment
Digitalization

HOW DO WE

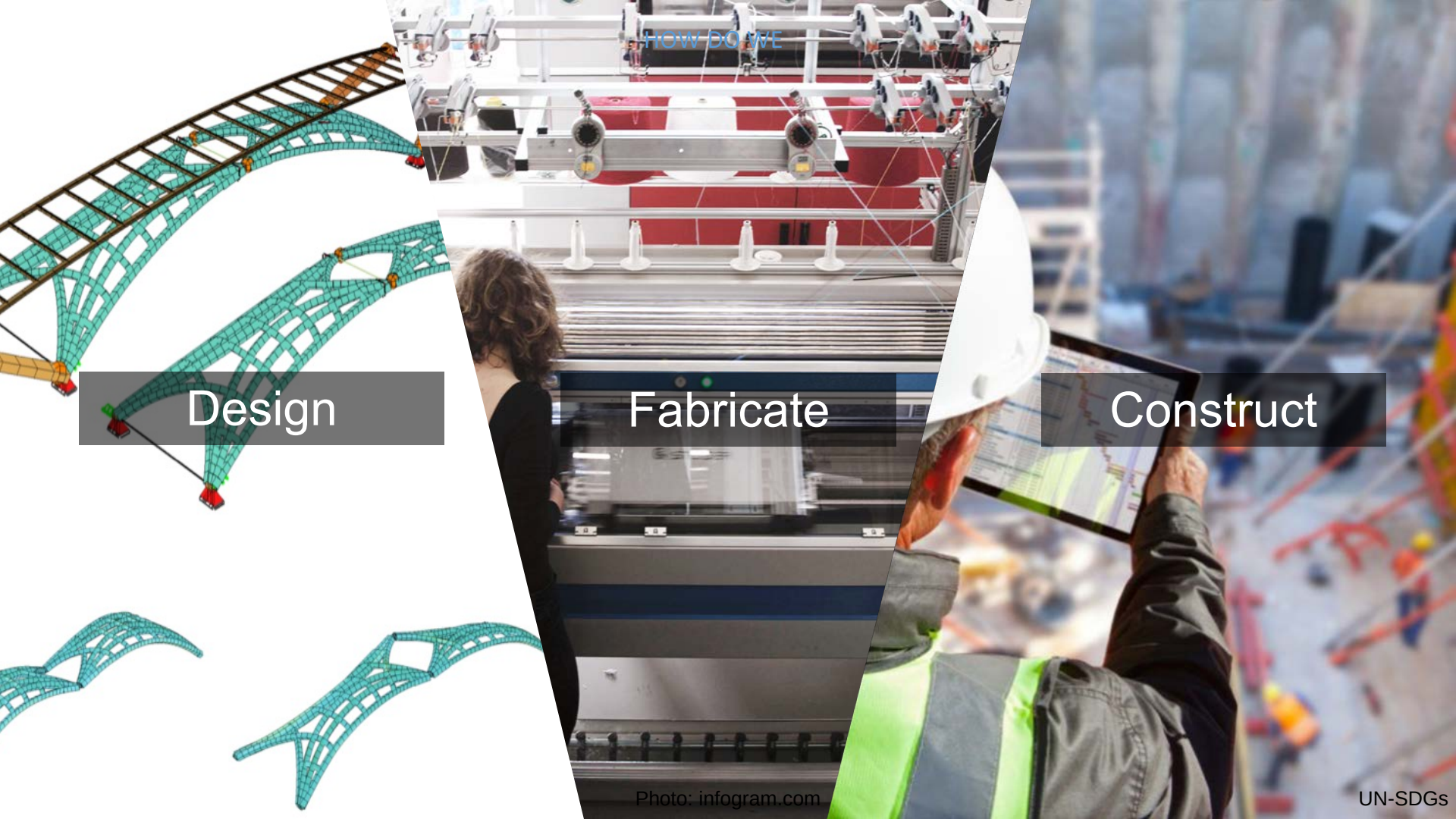


Photo: infogram.com

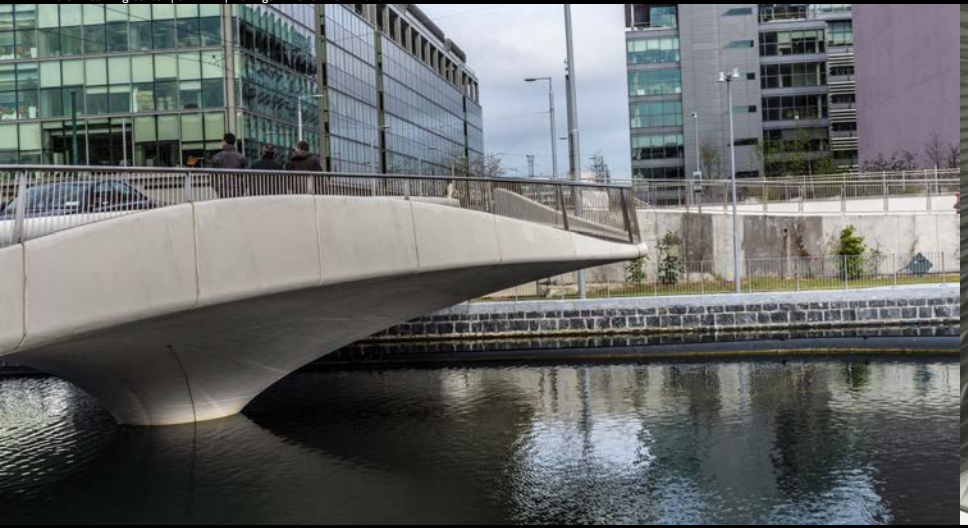
UN-SDGs

Digitalization Construction

Challenges associated with building complex concrete structures

EPFL – Rolex Learning center | SANAA | Bollinger + Grohmann 2010

Félix Candela | CMD Ingenieros 2003



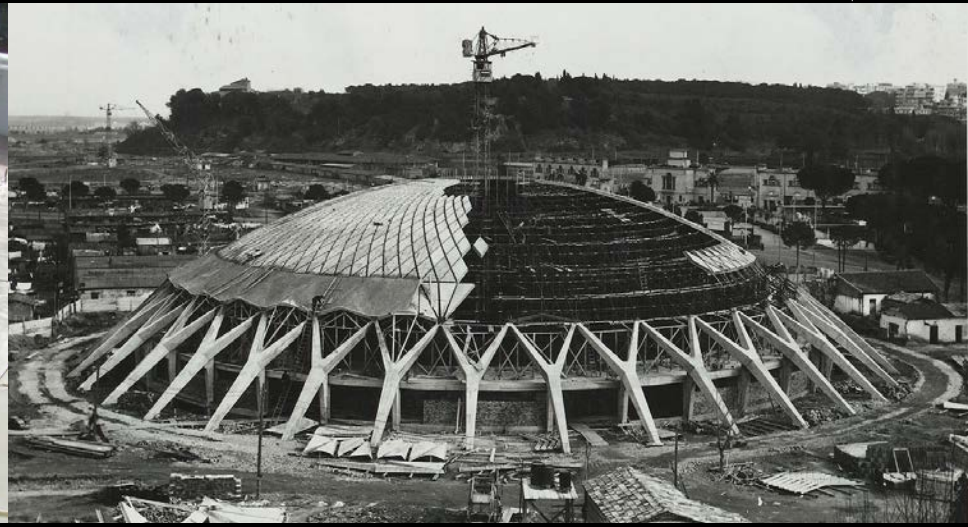
Spencer Dock bridge | Amanda Levete Architects | Arup 2009

Palazzo dello sport | Pier Luigi Nervi 1957

EPFL – Rolex Learning center | SANAA | Bollinger + Grohmann 2010

Los Manantiales | Felix Candela 1958

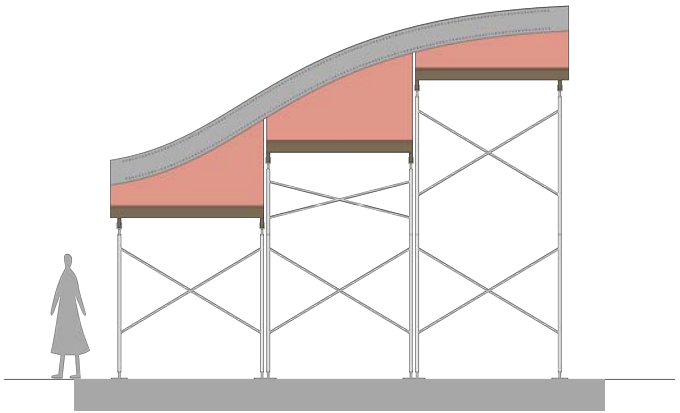
Spencer Dock bridge | Amanda Levete Architects | Arup 2009



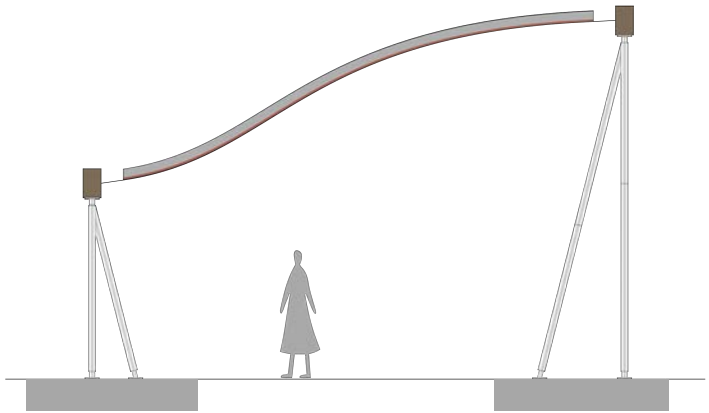
Palazzo dello sport | Pier Luigi Nervi 1957

photo: Maria Verhulst

Rigid vs flexible formwork



Traditional rigid formwork system



Flexible formwork system

Knitting - opportunities

- full 3D shaping
- minimal stitching
- branching
- channels/pockets/opening
- spacer fabrics
- tailored material placement


Non-orientable surface


Aramid fiber helmet | De Araujo et al. 2004

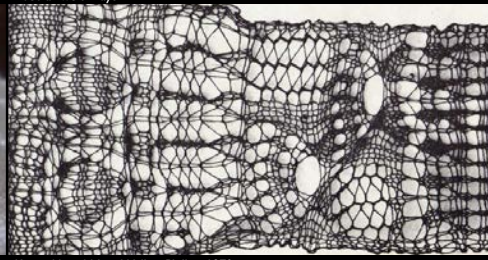

Biaxial reinforced shaped tubular structure | Bollengier et al. 2017


Six directional node

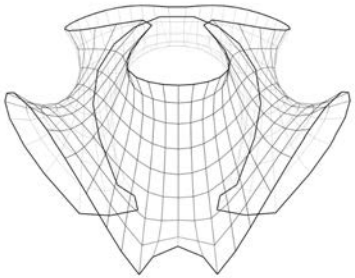

Biaxial reinforced spacer fabric | Abounaim et al. 2009


Tubular weft inlays

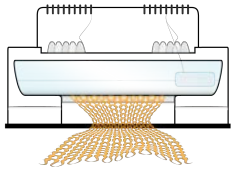

Biaxial reinforced rib stiffened structure | Bollengier et al. 2017


Knitted lace | Mary Walker Phillips 1970

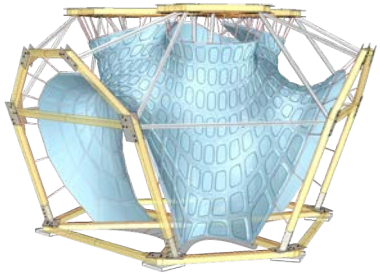
Design



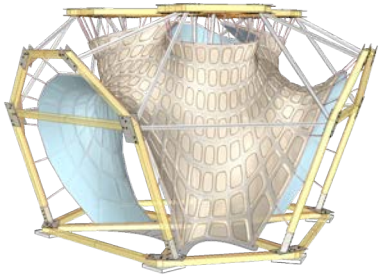
Knitting



Tensioning & coating



Formwork



KnitCandela

MUAC, Mexico City, Mexico, 2018

Design
Zaha Hadid Architects CODE: Filippo Nassetti, David Reeves, Marko Margeta, Shajay Bhooshan, Patrik Schumacher
Block Research Group, ETH Zurich: Mariana Popescu, Matthias Rippmann, Tom Van Mele, Philippe Block

Structural engineering
Block Research Group, ETH Zurich: Andrew Liew, Tom Van Mele

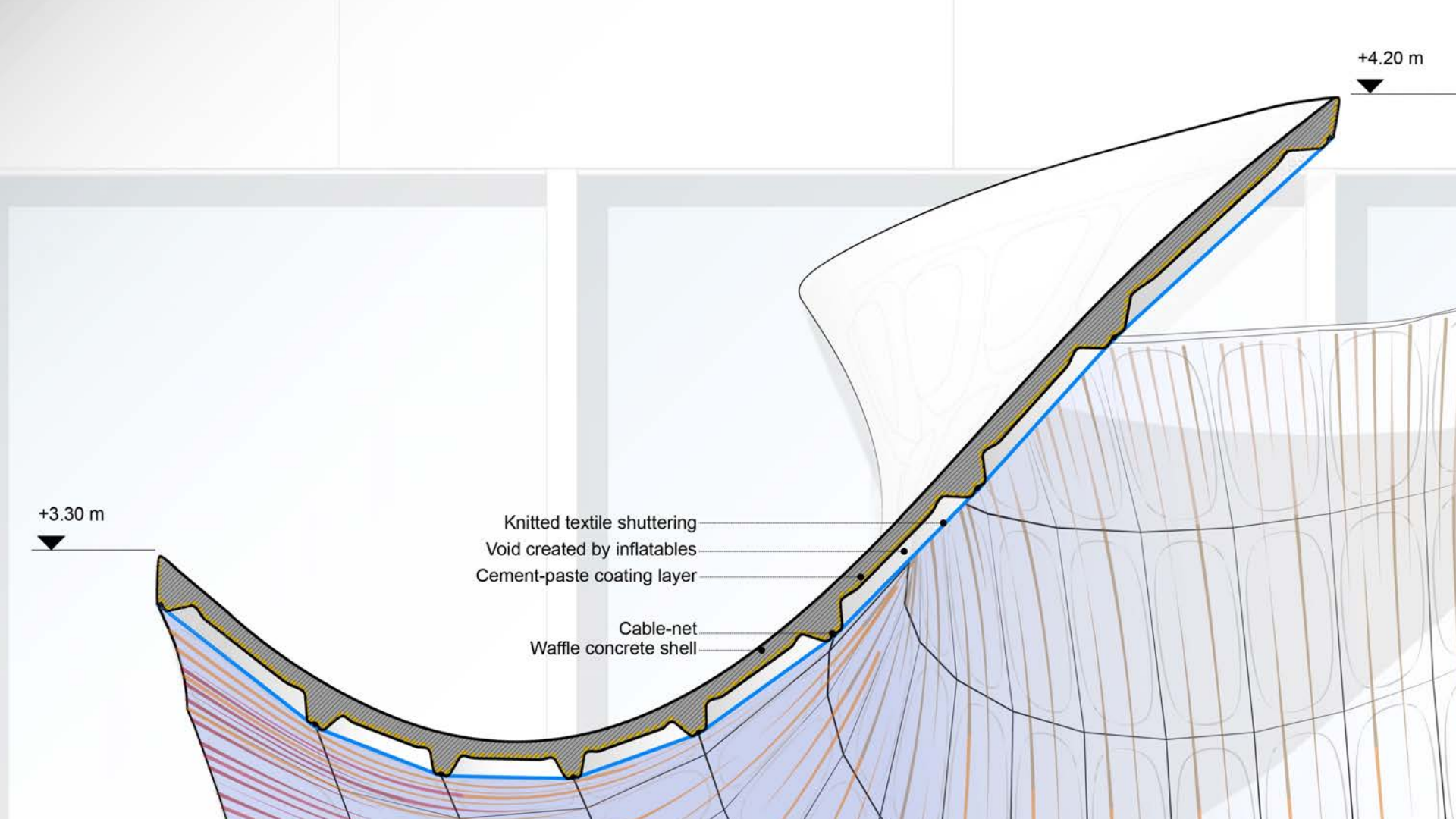
Fabrication
Block Research Group, ETH Zurich: Mariana Popescu, Matthias Rippmann

KnitCrete Technology
Block Research Group, ETH Zurich: Mariana Popescu, Tom Van Mele, Philippe Block
Physical Chemistry of Building Materials, ETH Zurich: Lex Reiter, Robert Flatt

Concrete development
Holcim Mexico

Site Coordination
Architecture Extrapolated: Alicia Nahmad Vasquez

photo: © Angelica Ibarra


+4.20 m
+3.30 m
Knitted textile shuttering
Void created by inflatables
Cement-paste coating layer
Cable-net
Waffle concrete shell

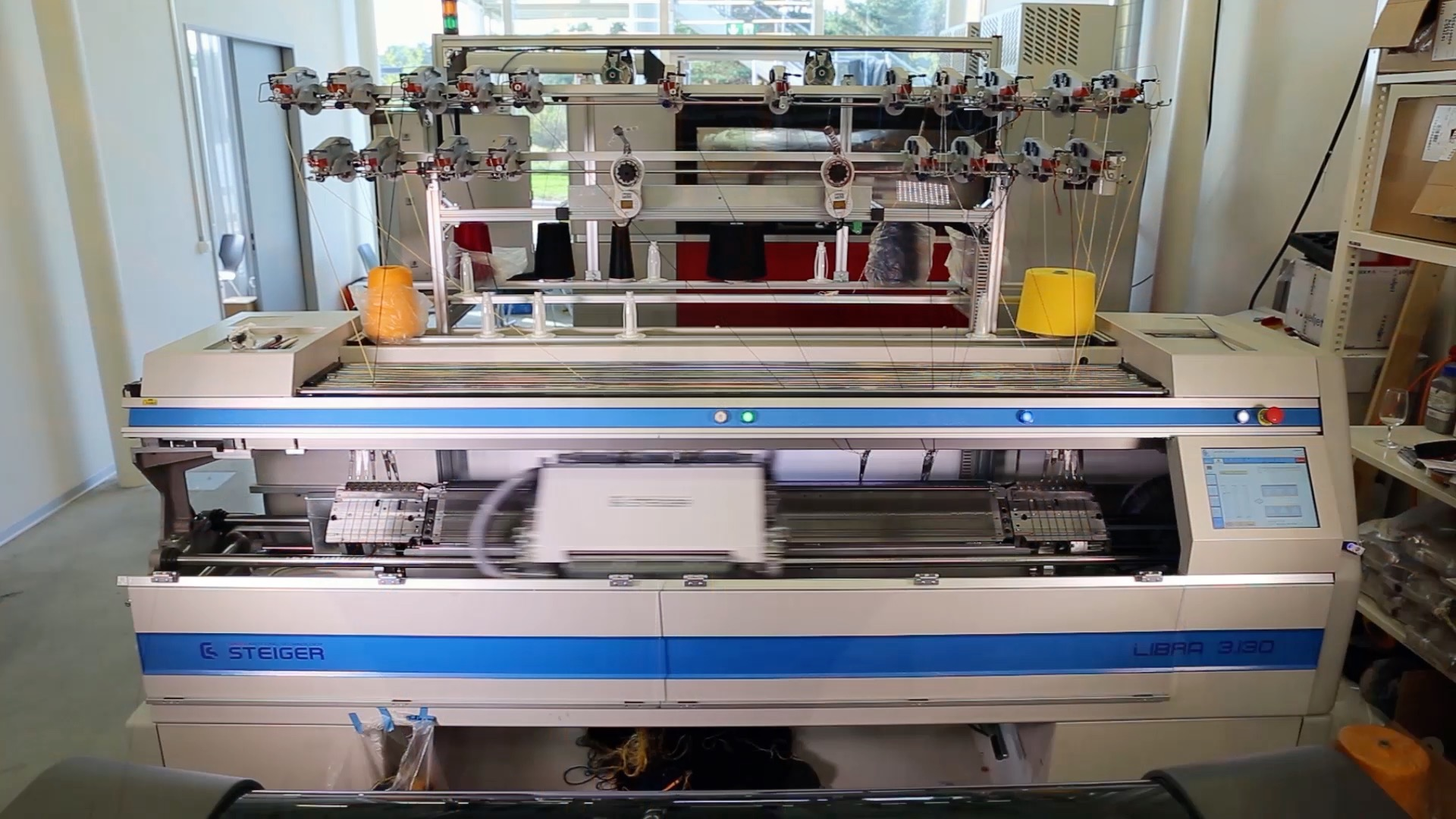
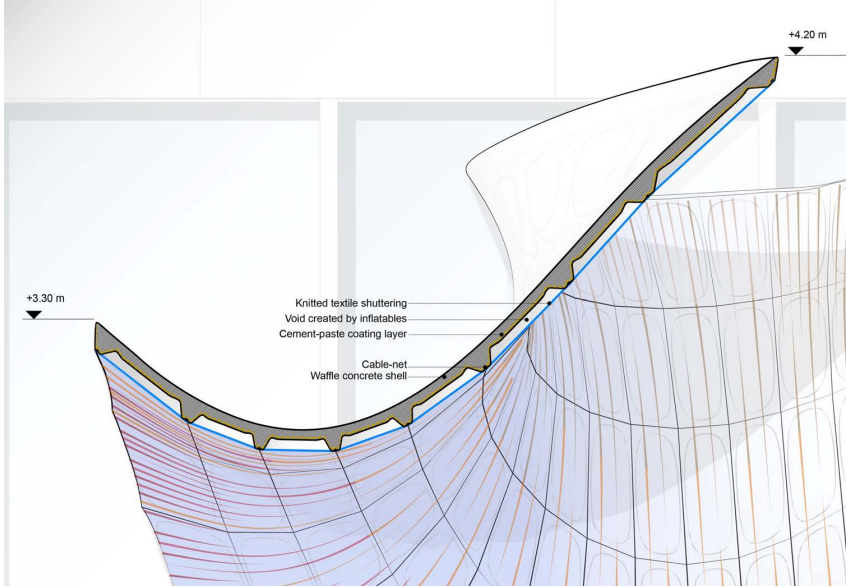

STEIGER
LIBRA 3130

photo: Lex Reiter

photo: Maria Verhulst


+4.20 m
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Knitted textile shuttering
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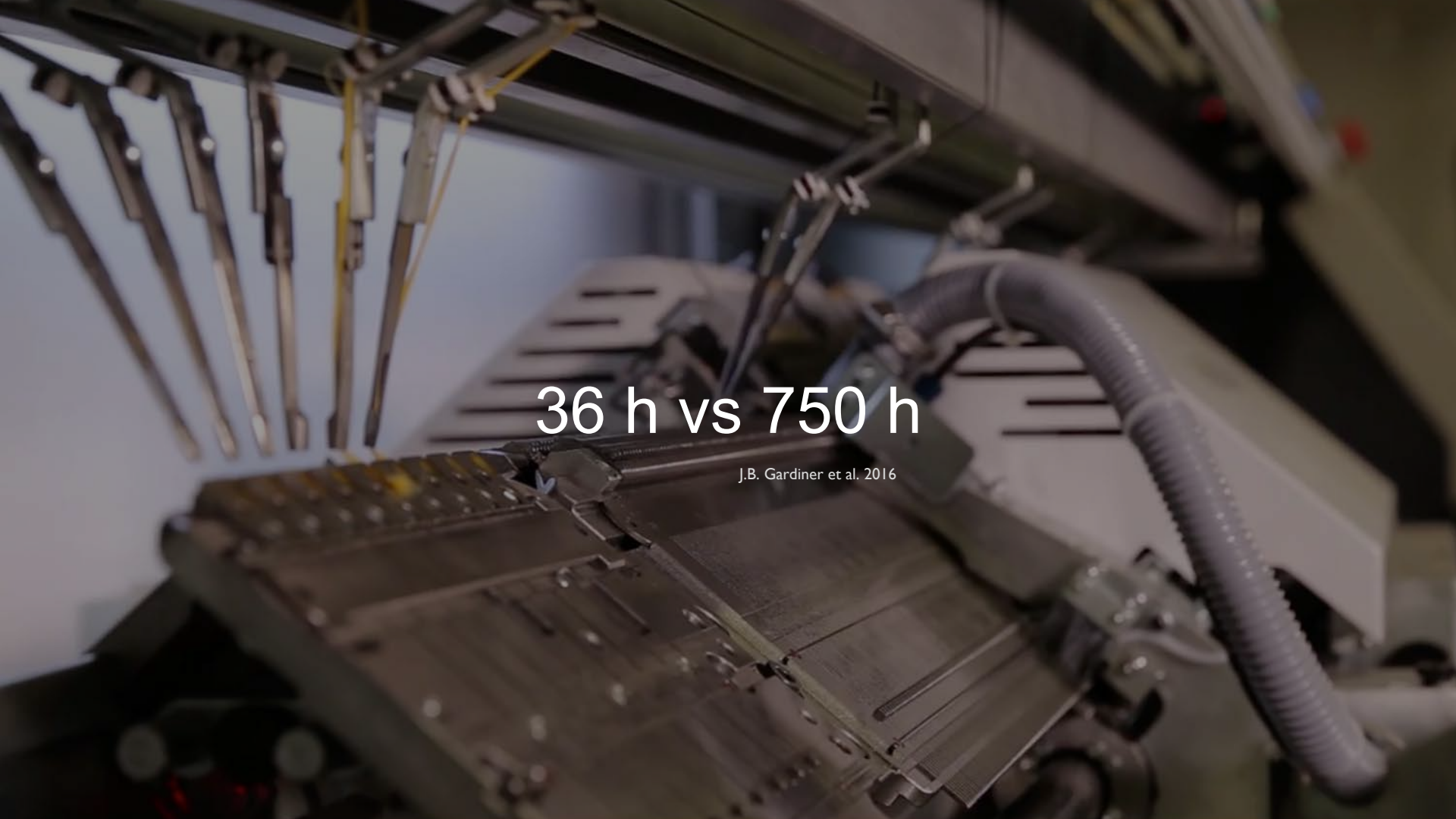
Waffle concrete shell

Photo: © Angelica Ibarra


EUR 2250
Maria Verhulst


25 kg



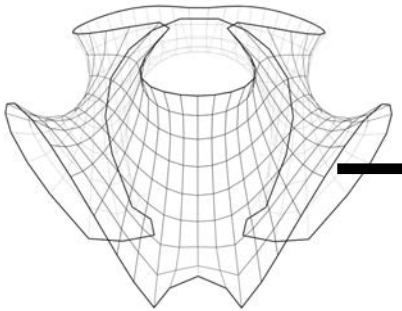
36 h vs 750 h

J.B. Gardiner et al. 2016

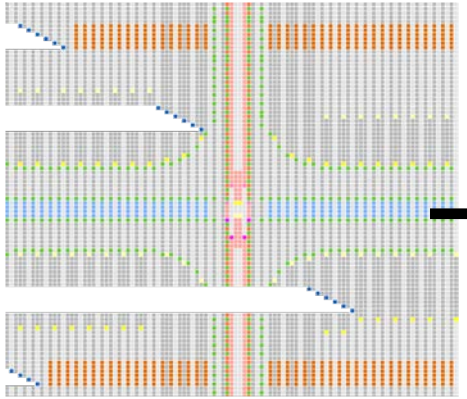

3 ½ months
© Angelica Ibarra

Computational pipelines

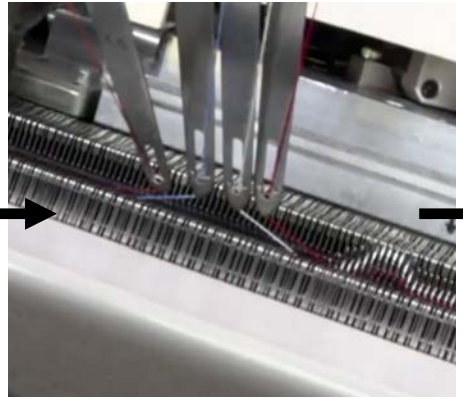
Design



Knitting pattern



Knitting



Knitted object

Video: Steiger participation Swiss knitting technology

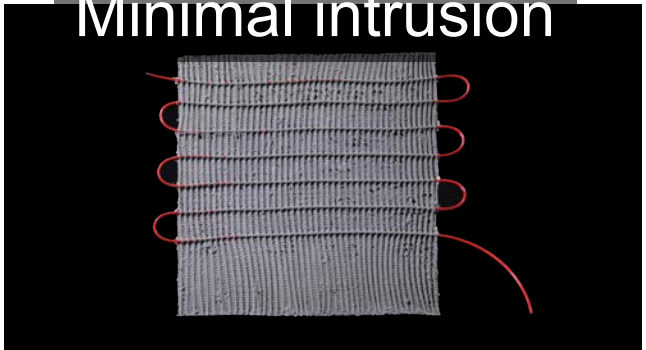
https://www.knittingindustry.com

Lightweight

Fast production

Waste reduction

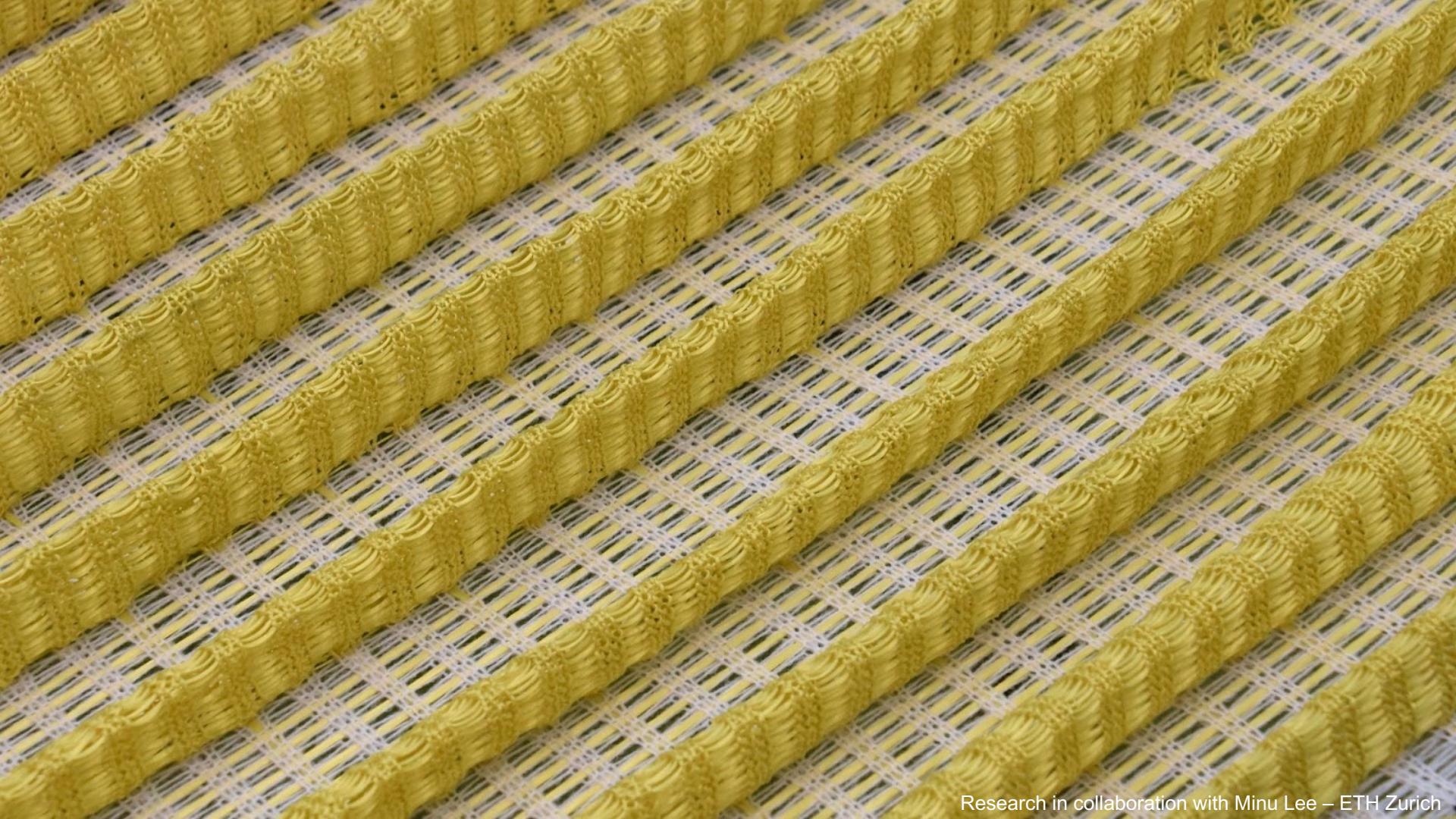
Minimal intrusion



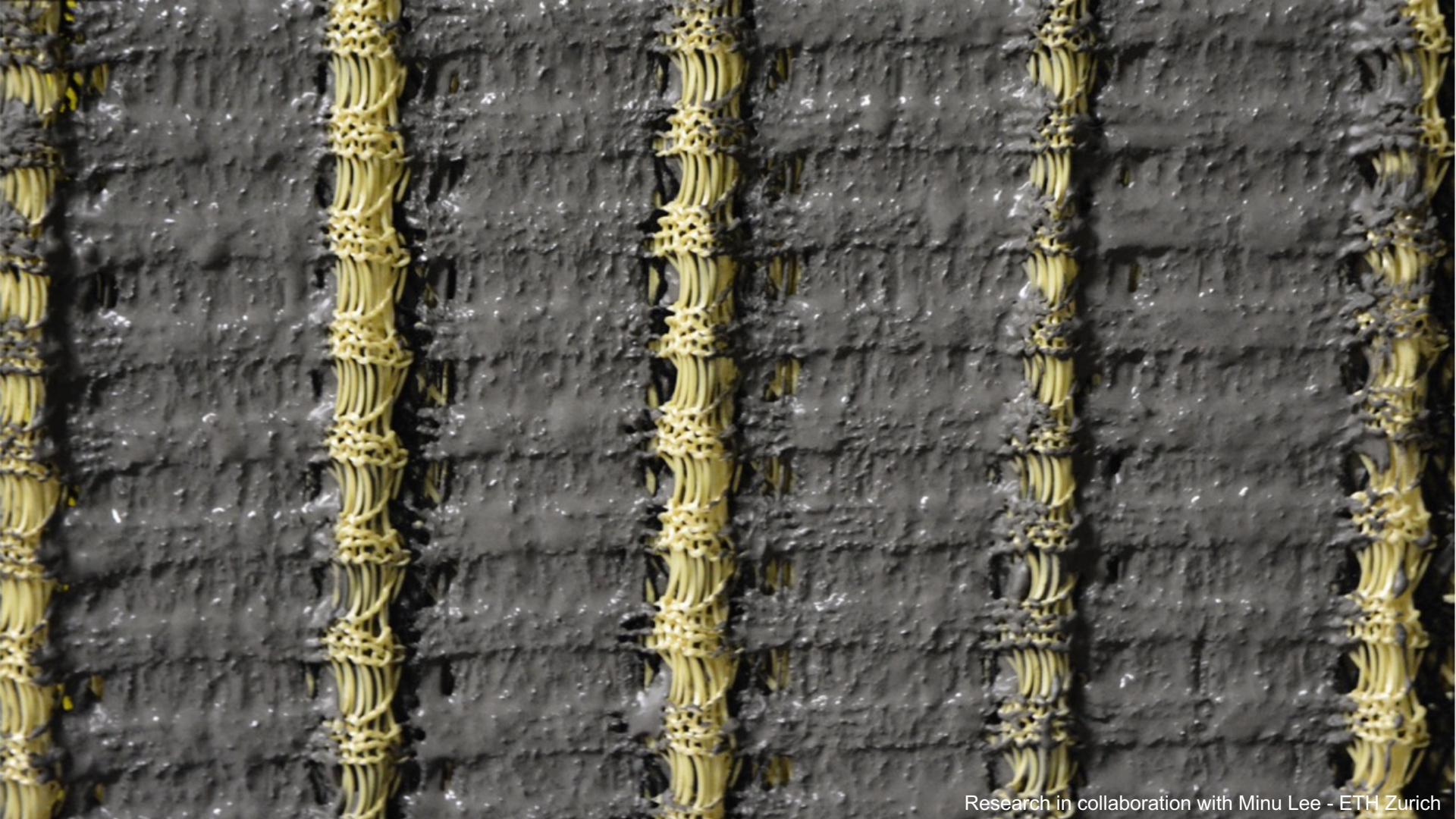
Concrete Reinforcement

NCCR Collaboration

Block Research Group: Mariana Popescu, Tom Van Mele, Philippe Block
Kaufmann Research: Minu Lee, Jaime Mata-Falcon, Walter Kaufmann



Research in collaboration with Minu Lee – ETH Zurich



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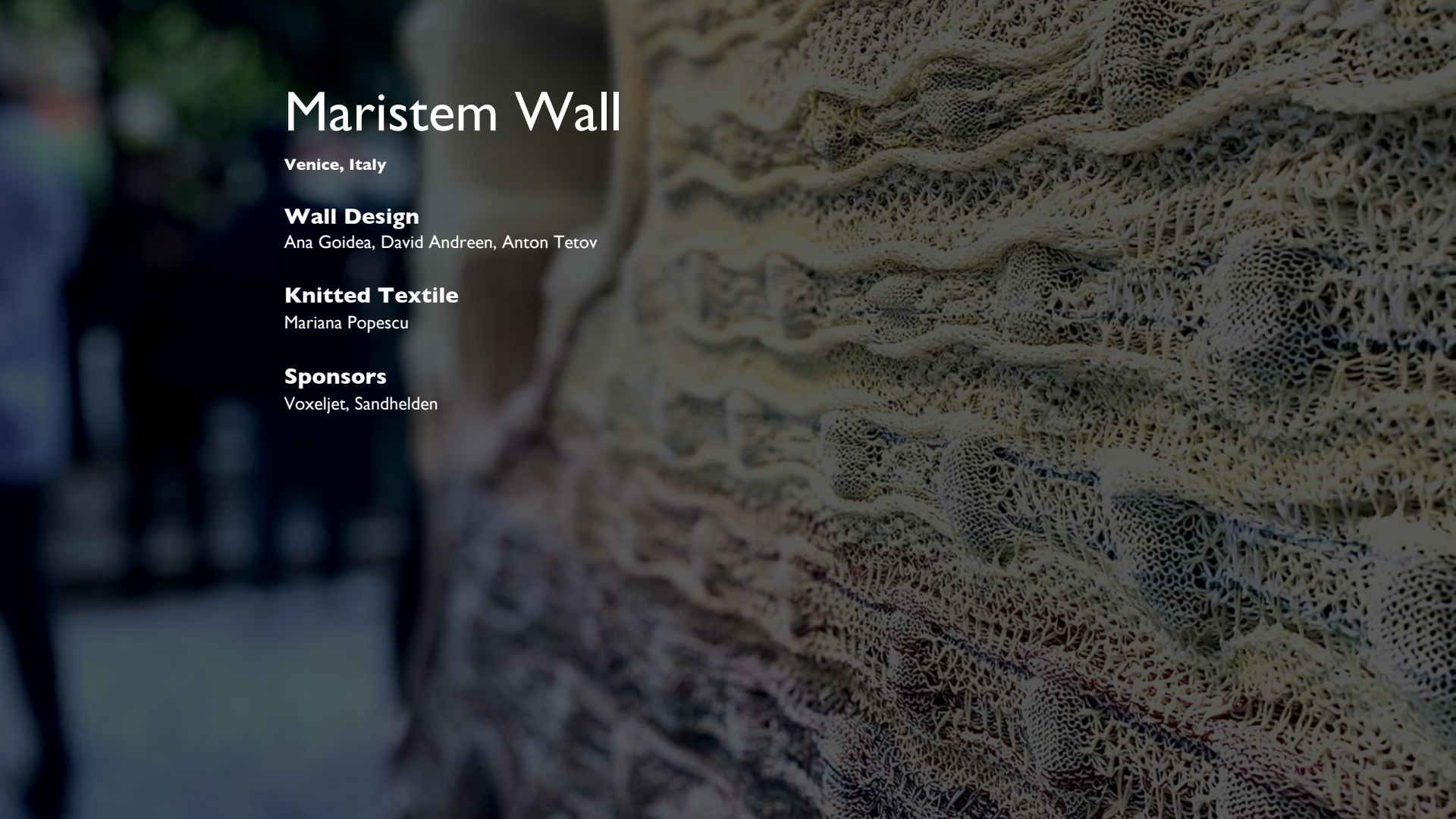


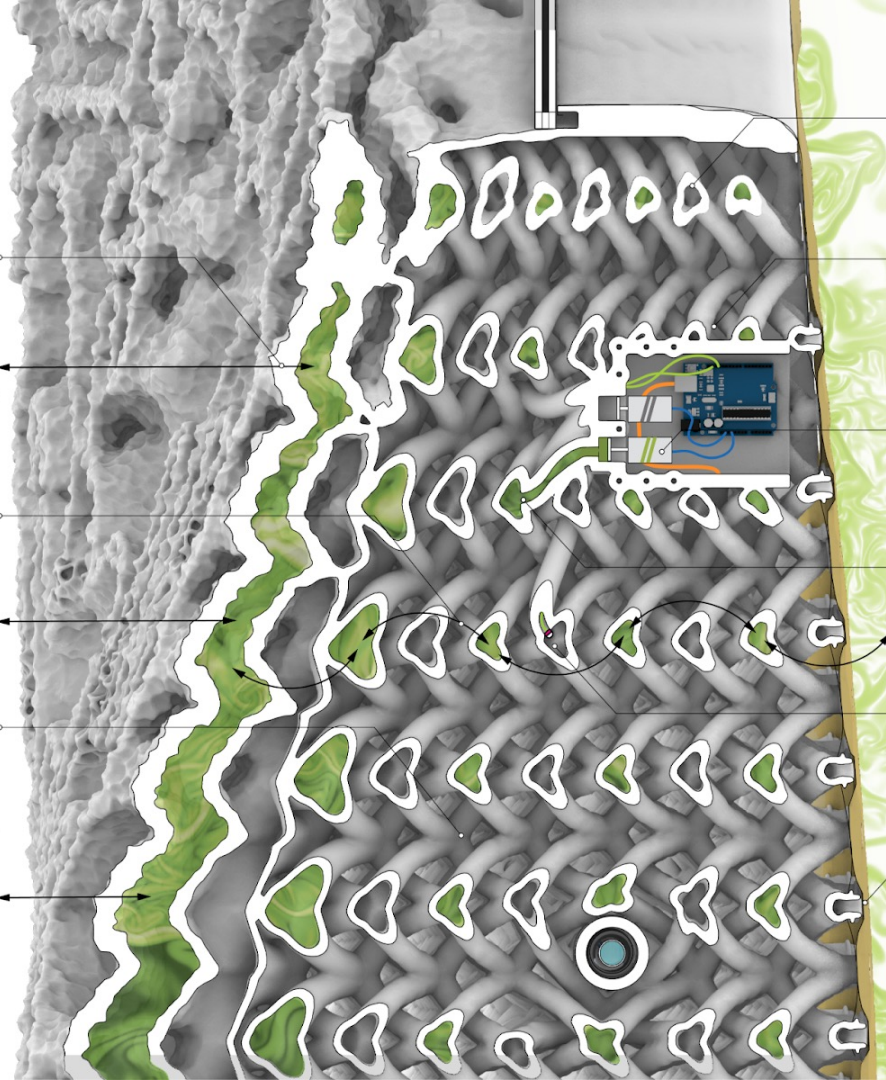
Maristem Wall

Venice, Italy

Wall Design
Ana Goidea, David Andreen, Anton Tetov

Knitted Textile
Mariana Popescu

Sponsors
Voxeljet, Sandhelden



external exchange

Through their connection to the external layer, the channels can access intermittent dry, wet, warm or cool air to mediate the internal climate. The connection also supports the ecosystem in the wall's external zone, ameliorating the micro-climate and habitat.

transient mass transport

The high tortuosity channels block pressure induced cross flow, but can be activated through oscillation-induced turbulence. Two independent networks and location specific effects through frequency and amplitude manipulation allow a high degree of flow control.

interstitial buffer / insulation

The interstitial space is used depending on local climate and micro-climate. Insulation limits heat transfer – buffer materials such as phase change salts interact with the controllable airflows in the channels for highly efficient thermal storage.

inactive channels

Mass transfer is selectively applied; inactive channels limit the flow of air through the structure.

cybernetic controller

An accessible, simple controller controls the actuators in response to sensor readouts. Through the electronic rather than mechanical interface, the wall's function can be altered and improved through software updates.

oscillation actuators

Solenoid actuators minimise mechanical complexity, and transfer oscillation energy to the air mass.

actuation channels

The oscillation wave is transfered through static air channels to the active part of the network, eliminating the need to embed complex machines in the wall's interior.

embedded sensors

Sensors embedded throughout the channel network provides real-time data on humidity, temperature, and gas concentrations.

textile filter

The textile covers the internal openings, allowing flow of air but filters large particles and insects.


Thank you