

Concrete stays / *From Smart Dynamic Casting to Thin formworks*

Prof. Dr. Ena Lloret-Fritschi

Swissbau 17th January 2024



4.4 billion ton of concrete is produced pr. year = total 7% CO2 emission



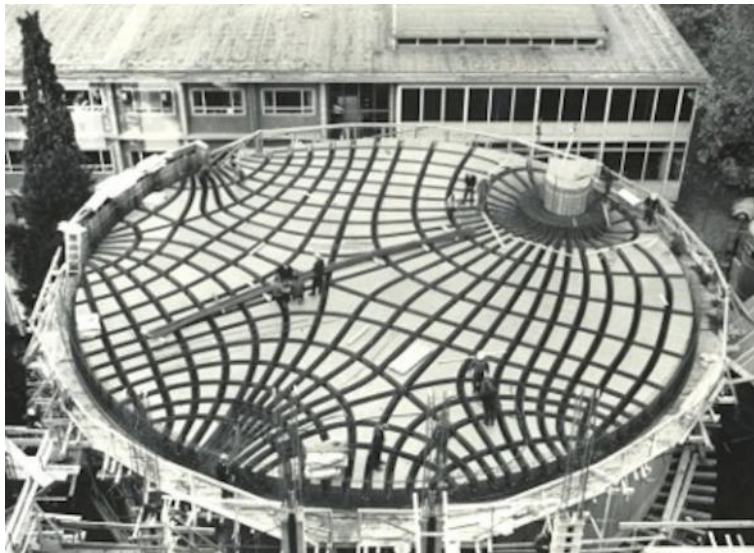
Lecture Hall Zoological Institute University Freiburg
Hans Dieter Hecker (1968)



014 Tower, Riser Uamoto, 2012



Bosjes Chapes Steyn Studio, 2018



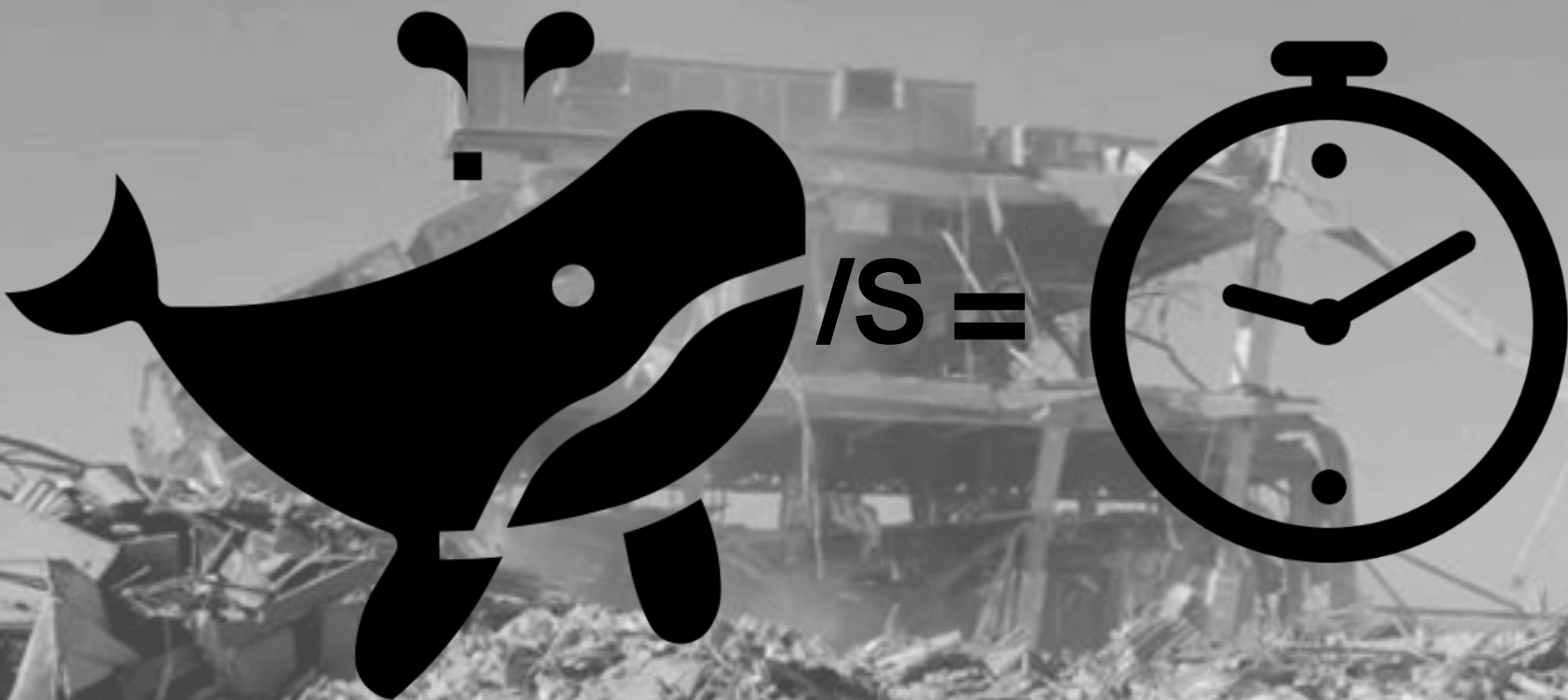


All other
waste

Annual Waste in Switzerland

84%

of total waste produced in the construction sector
Federal Office for the Environment (FOEN)

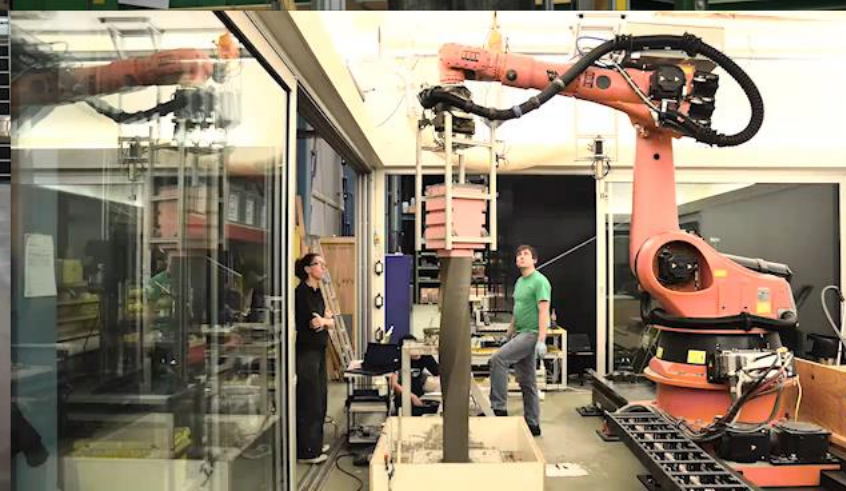
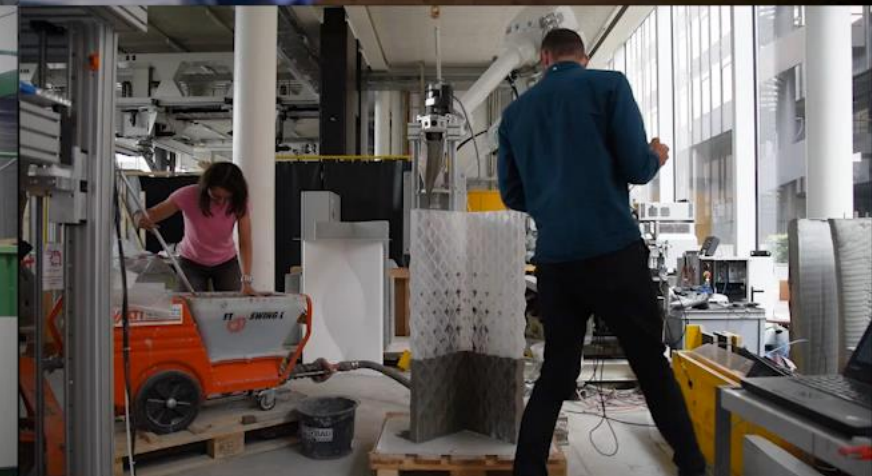
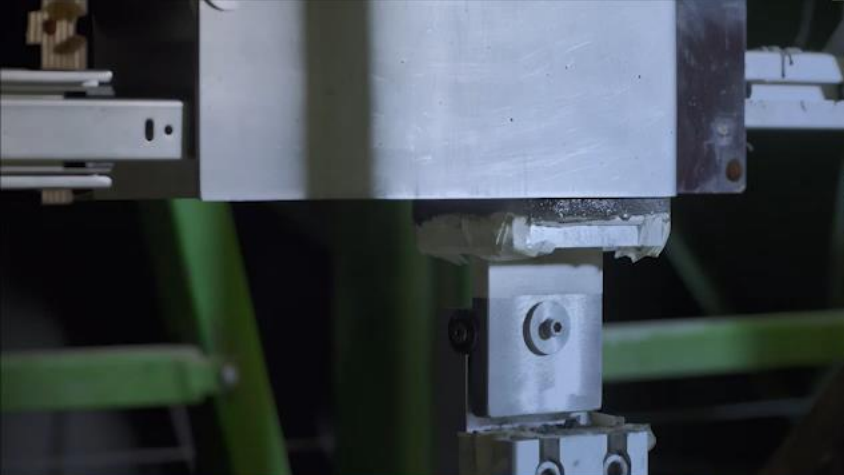


*Annual Waste in
Switzerland*

500Kg/

Sec

*Construction
Waste generated*



Material Control & Processing

Too Soft



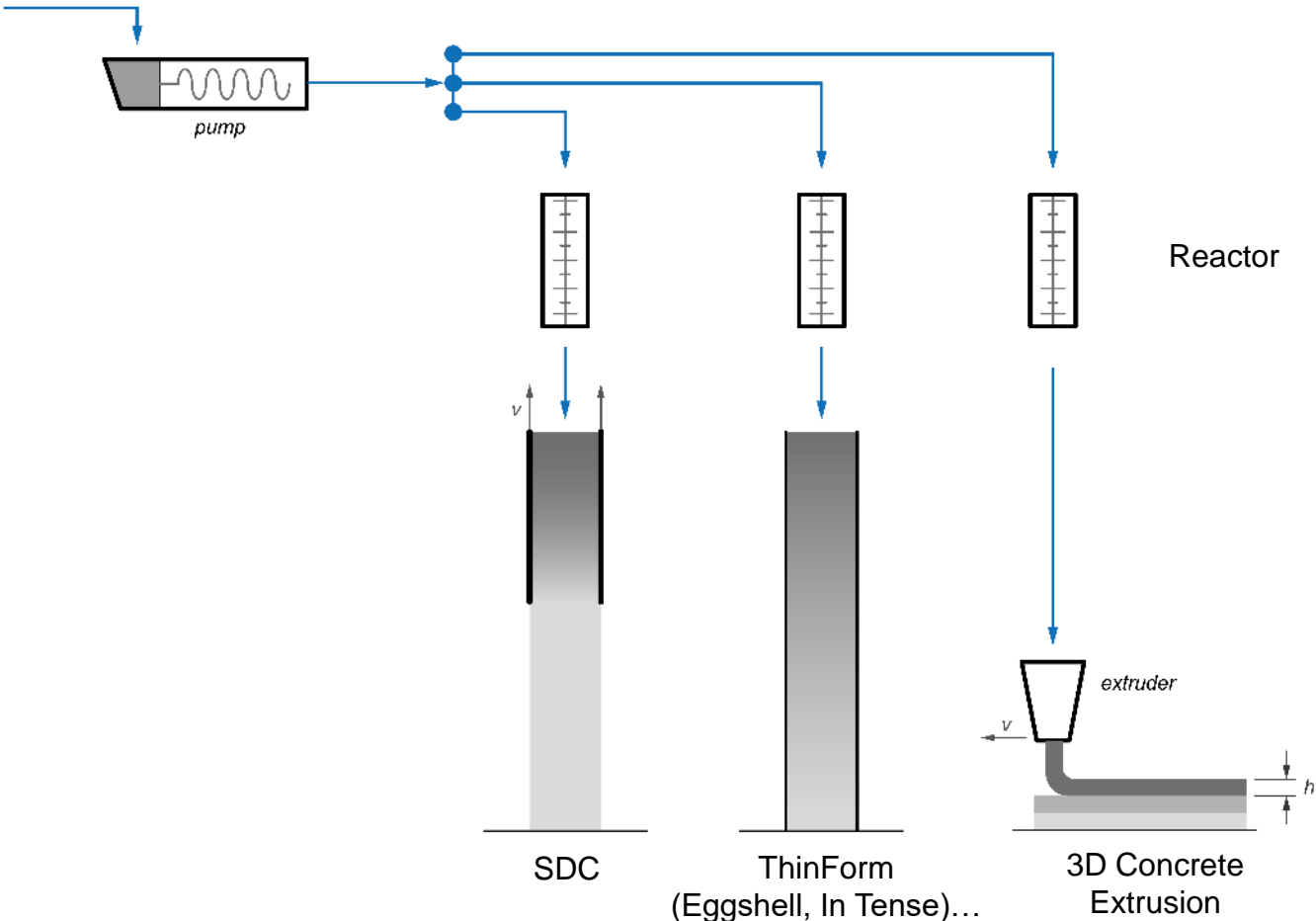
Too Hard



Robotic slipforming for non-standard structures
Lloret-Fritschi, 2016

Digital Casting Systems Set-On-Demand Processing

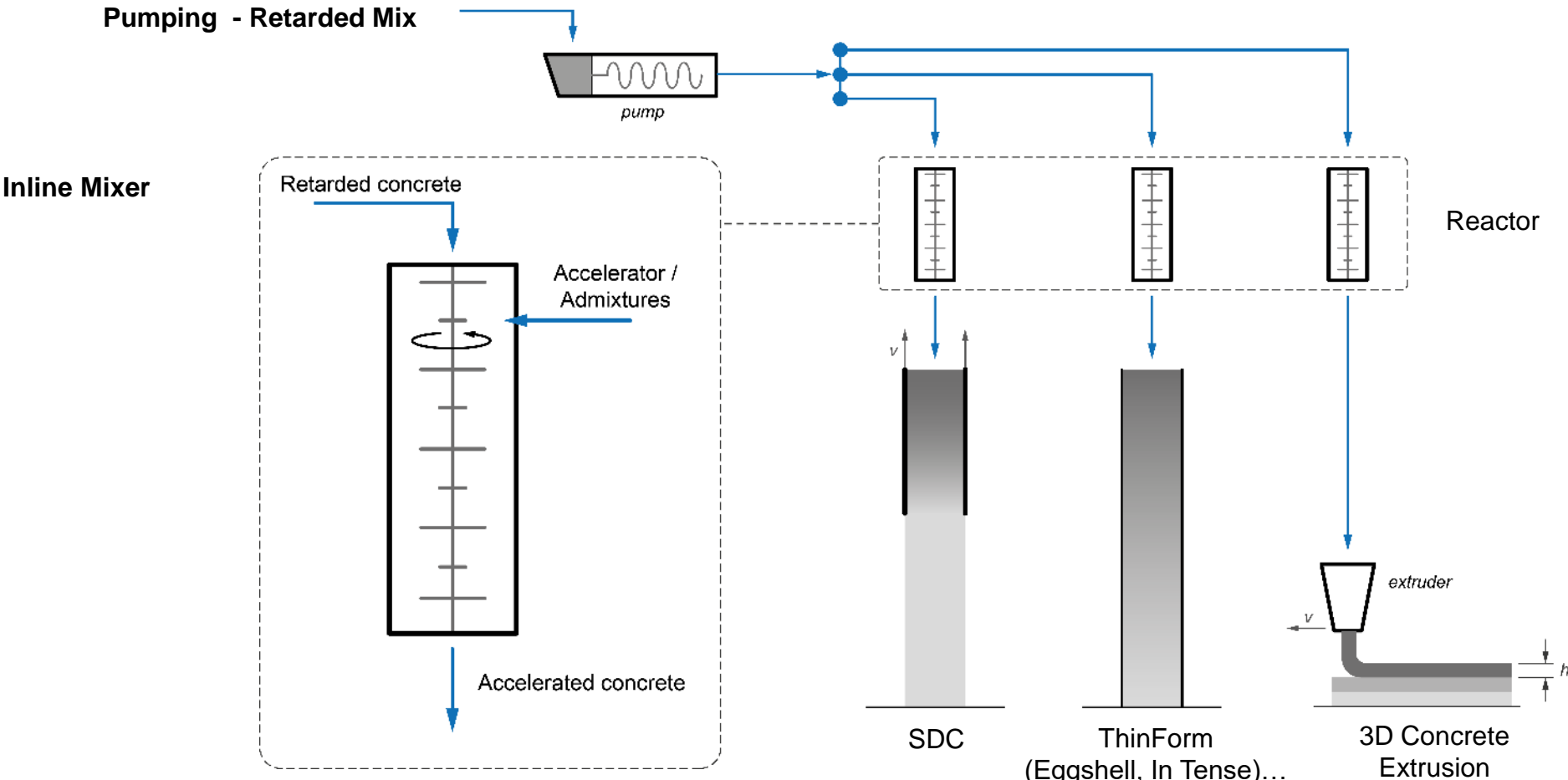
Pumping - Retarded Mix



From Smart Dynamic Casting to a growing family of Digital Casting Systems,
Lloret et al, Cement and Concrete Research, Vol 138, 2020



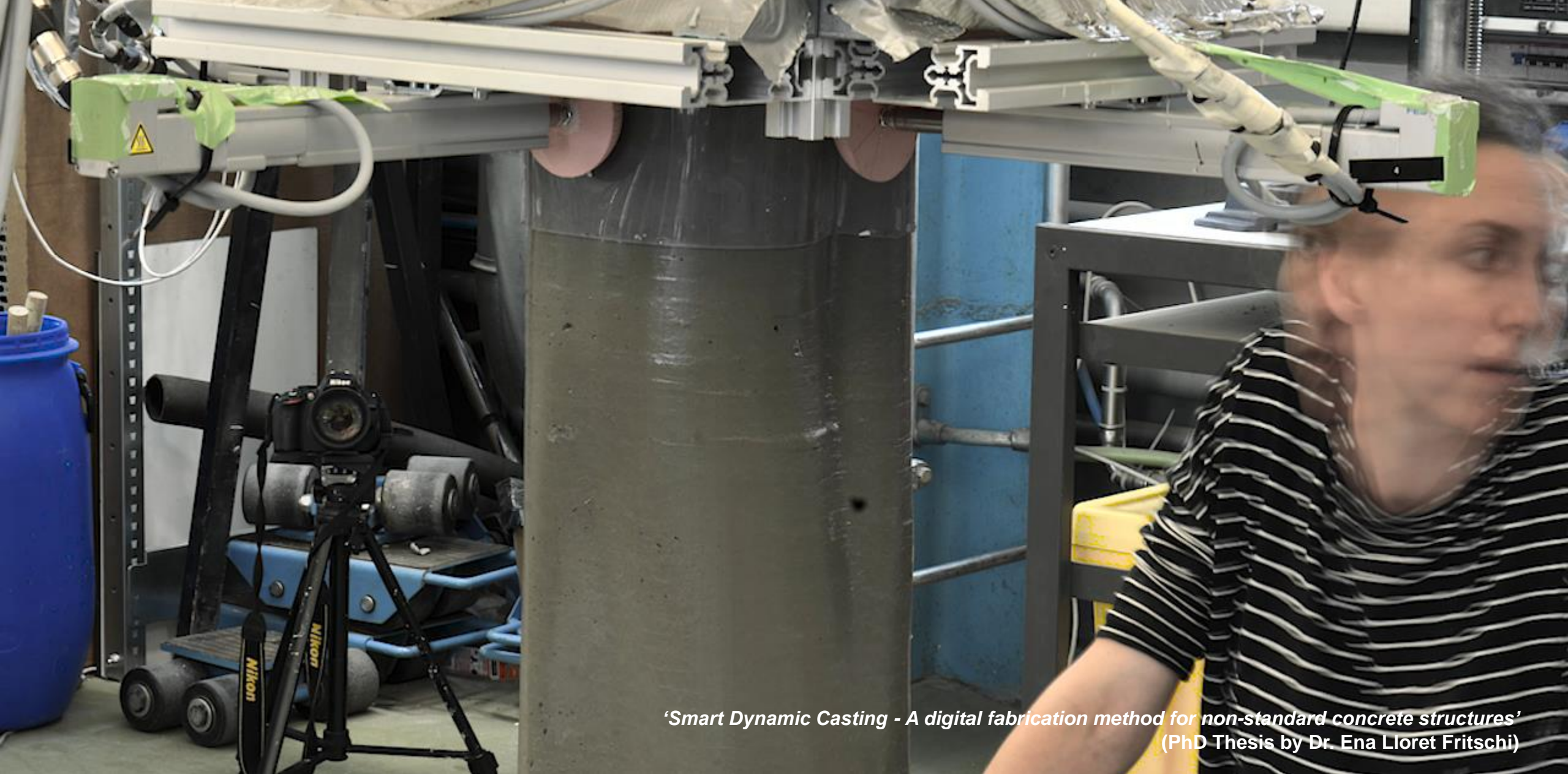
Digital Casting Systems Set-On-Demand Processing



From Smart Dynamic Casting to a growing family of Digital Casting Systems, Lloret et al, Cement and Concrete Research, Vol 138, 2020

Rigid Formwork

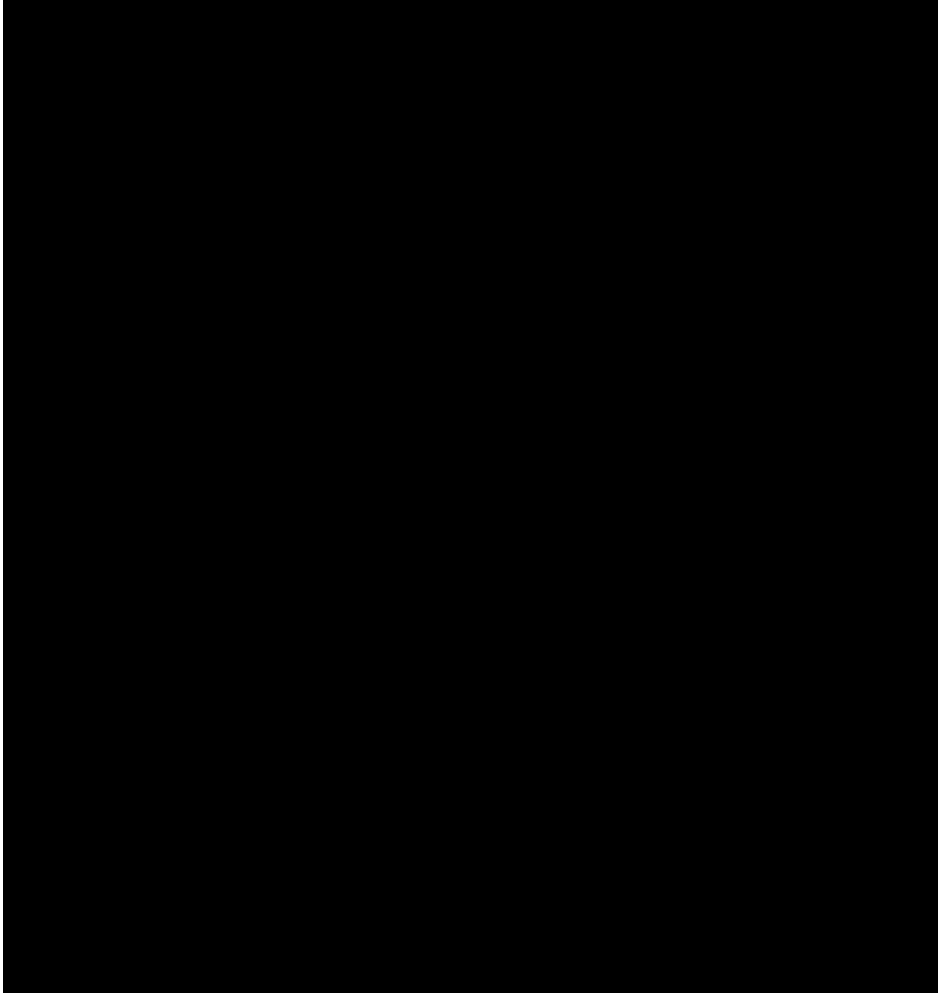
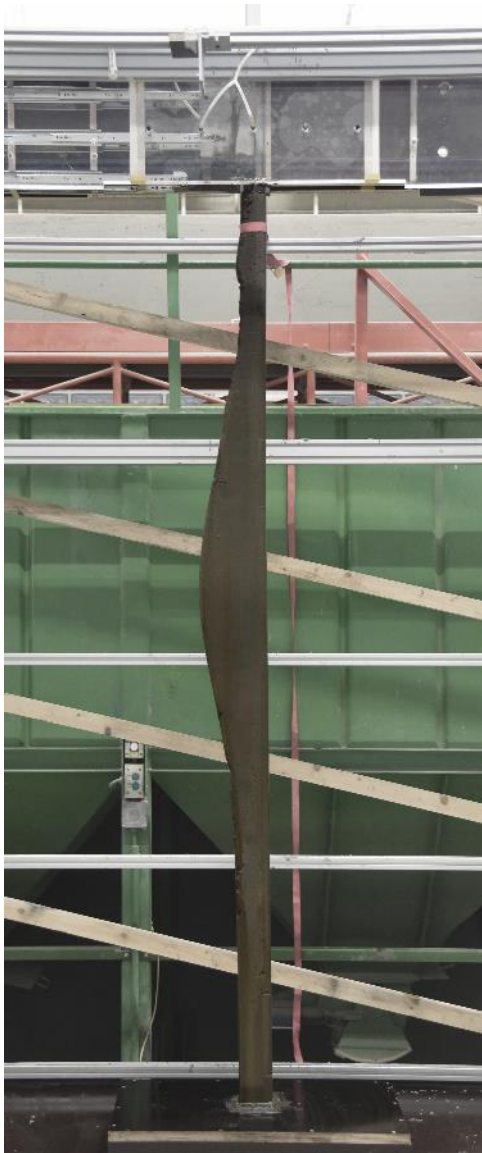




'Smart Dynamic Casting - A digital fabrication method for non-standard concrete structures'
(PhD Thesis by Dr. Ena Lloret Fritschi)

DFAB HOUSE











30% less material

Bild: Roman Keller



Eggshell

Ultra-Thin Formwork for Concrete

PhD Joris Burger

Fabio Scotto, Ena Lloret Fritschi, Gramazio Kohler Research, Chair of Architecture and Digital Fabrication, ETH Zurich

Prof. Robert Flatt, Institute for Building Materials, ETH Zurich

NCCR Digital Fabrication, ETH Zurich

ETH zürich

DARCH

Departement Architektur



**GRAMAZIO
KOHLER
RESEARCH**

IfB

Institut für Baustoffe
Institute for Building Materials

Eggshell

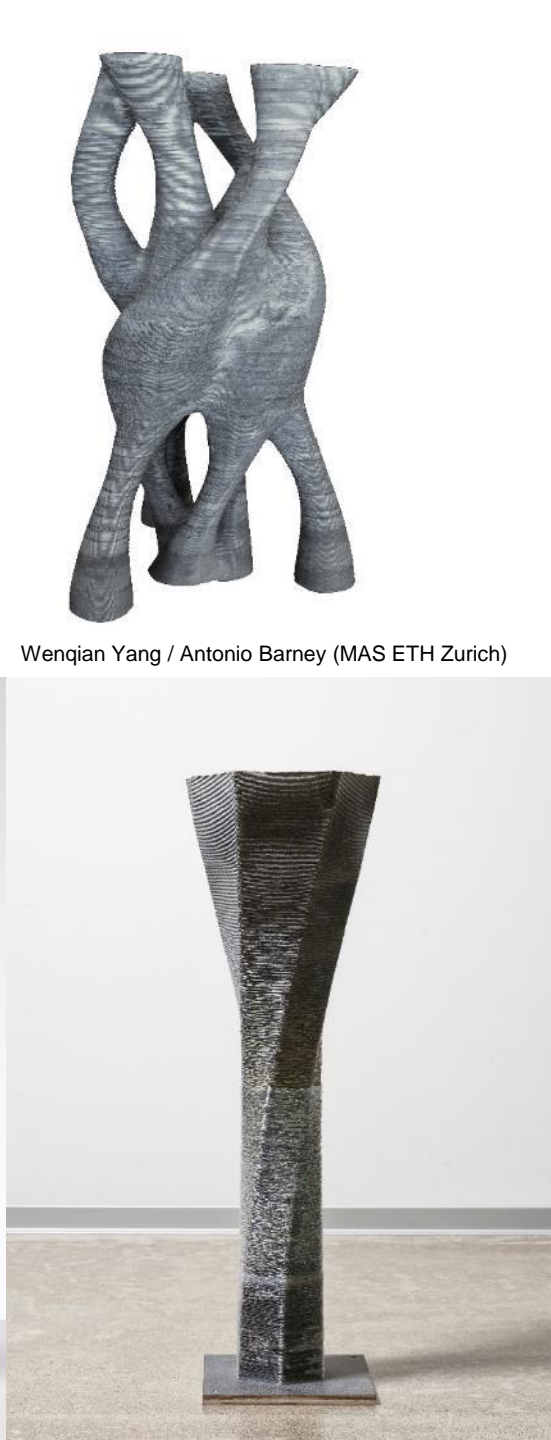


MAS Digital Fabrication, ETH

Antonio Barney & Wenqian Yang, Tutors: Joris Burger & Lukas Gebhard, 2019

GKR, PCBM ETH





Wenqian Yang / Antonio Barney (MAS ETH Zurich)

Wenqian Yang / Antonio Barney (MAS ETH Zurich)

Future Tree

Research & Construction Project 2017-2019

Gramazio Kohler Research, Architecture & Digital Fabrication, ETH Zurich

Team: Dr. Aleksandra Anna Apolinarska, Dr. Ena Lloret-Fritschi, Joris Burger, Nizar Taha, Fabio Scotto

In cooperation with: Physical Chemistry of Building Materials group (ETH Zurich, Prof. Dr. Robert J. Flatt, Dr. Thibault Demoulin, Bruno Pinto Aranda)

Selected experts: Basler & Hofmann AG, ERNE AG Holzbau, SJB Kempter Fitze AG, Concrete Structures & Bridge Design (ETH Zurich, Prof. Walter Kaufmann, Dr. Jaimé Mata-Falcon)

Selected contractors: ERNE AG Holzbau (Fabrication timber structure)

Client: Basler & Hofmann AG

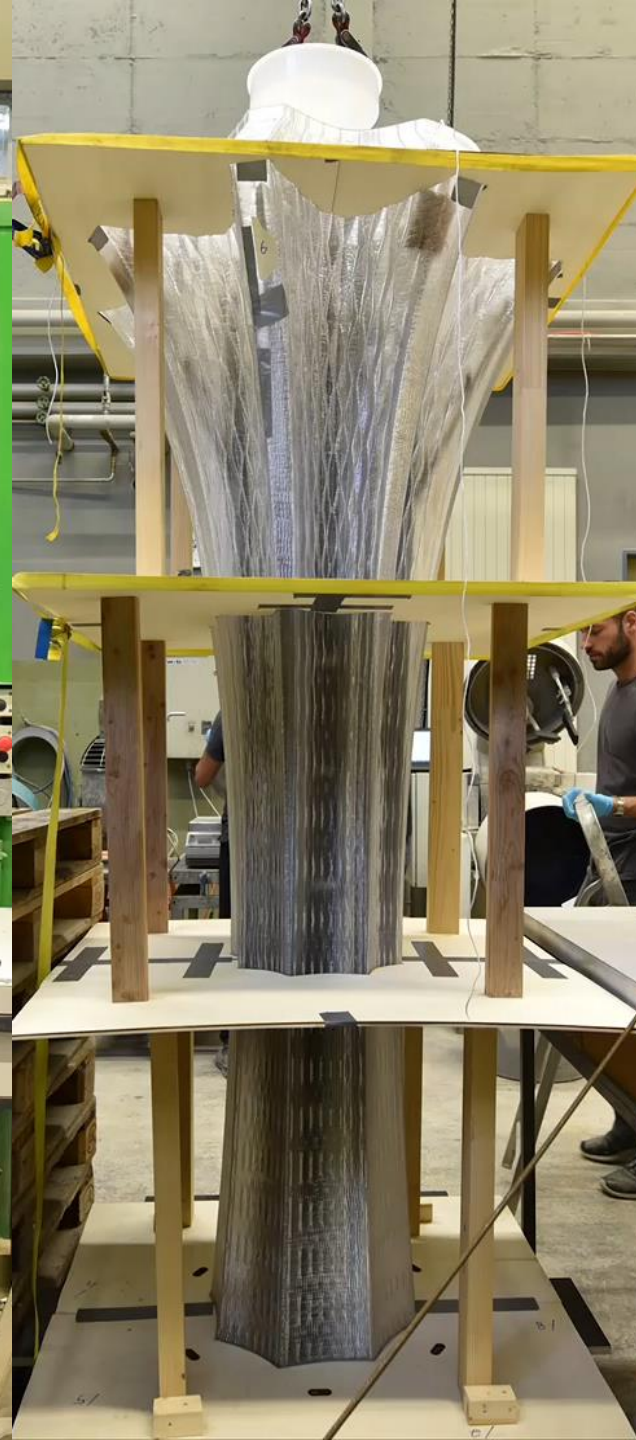
GRAMAZIO
KOHLER
RESEARCH
ETH ZÜRICH

ETH zürich

Basler & Hofmann

ERNE
wir bauen vorwärts





Prototypes



#1



#2



#3



#4







Full-scale, reinforced column
1.5mm thin 3D printed formwork
Digital Casting System

Gramazio Kohler Research, PCBM
ETH Zurich

Paper Formworks

Increase

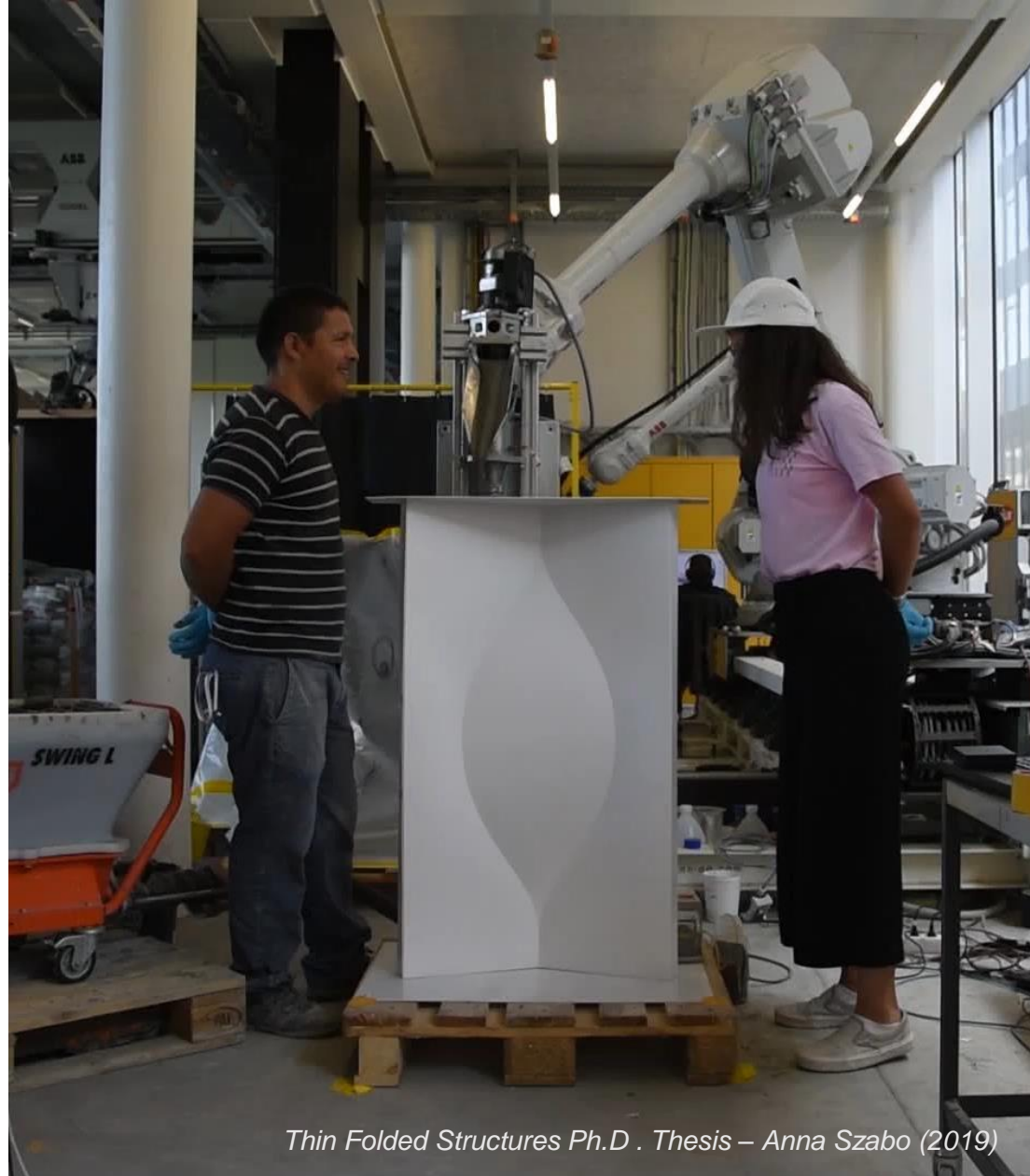
Anna Szabo, Fabio Scotto, Robert Flatt, Joseph Choma, Ena Lloret-Fritschi

GRAMAZIO
KOHLER
R E S E A R C H
E EA

ETH zürich

Paper = cheap / recyclable / foldable





Thin Folded Structures Ph.D . Thesis – Anna Szabo (2019)



Image: InCrease
E. Lloret-Fritschi, F. Scotto, A. Szabo, R.J Flatt (ETH) & J. Choma (Clemson)

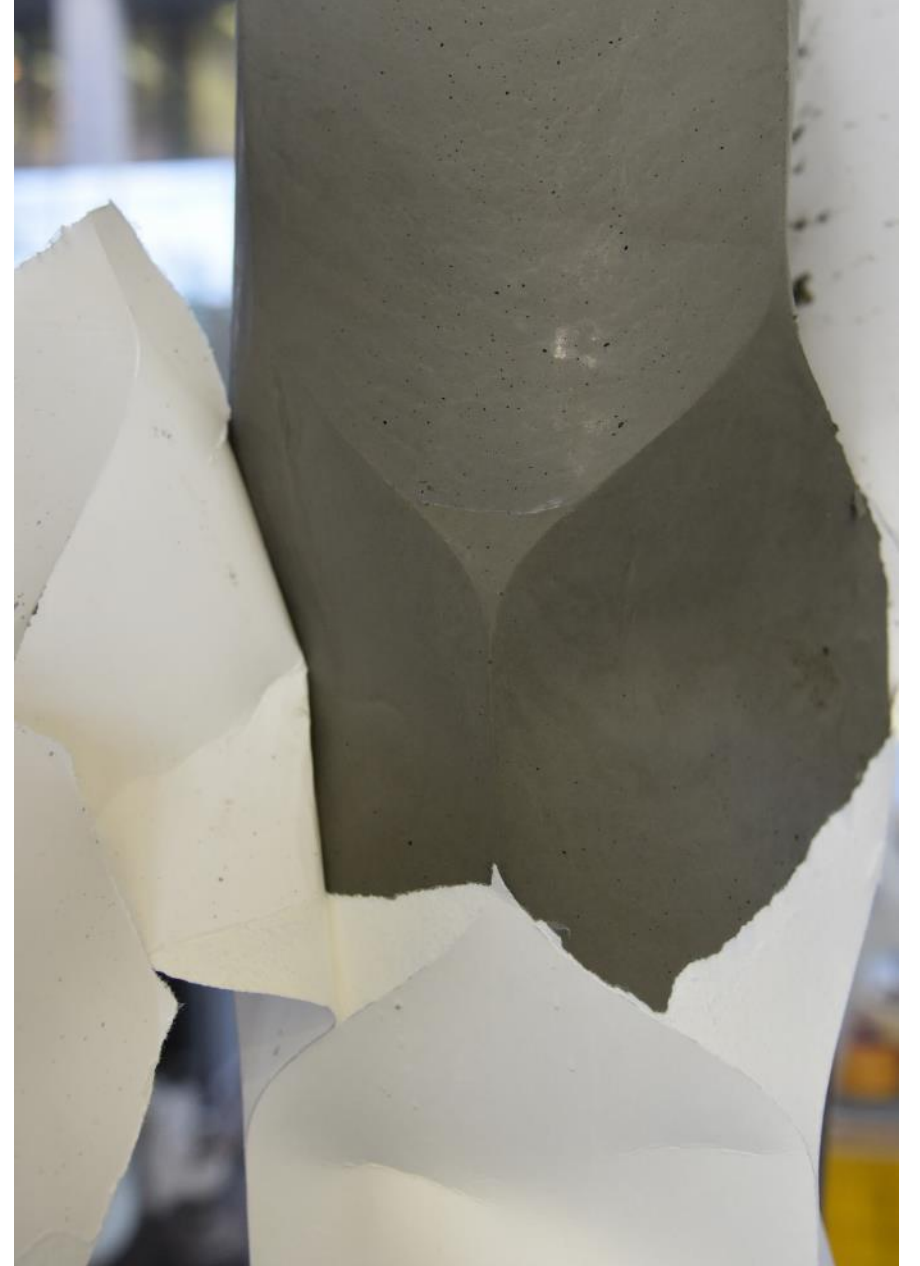




Image: InCrease
E. Lloret-Fritschi, F. Scotto, A. Szabo, R.J Flatt (ETH) & J. Choma (Clemson)

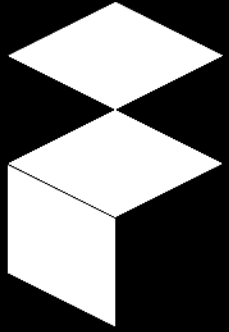


Image: InCrease

E. Lloret-Fritschi, F. Scotto, A. Szabo, R.J Flatt (ETH) & J. Choma (Clemson)

Image: InCrease

E. Lloret-Fritschi, F. Scotto, A. Szabo, R.J Flatt (ETH) & J. Choma (Clemson)



Foldcast

Paper-based moulds for concrete construction

PhD Fabio Amicarelli

Prof. Ena Lloret Fritschi

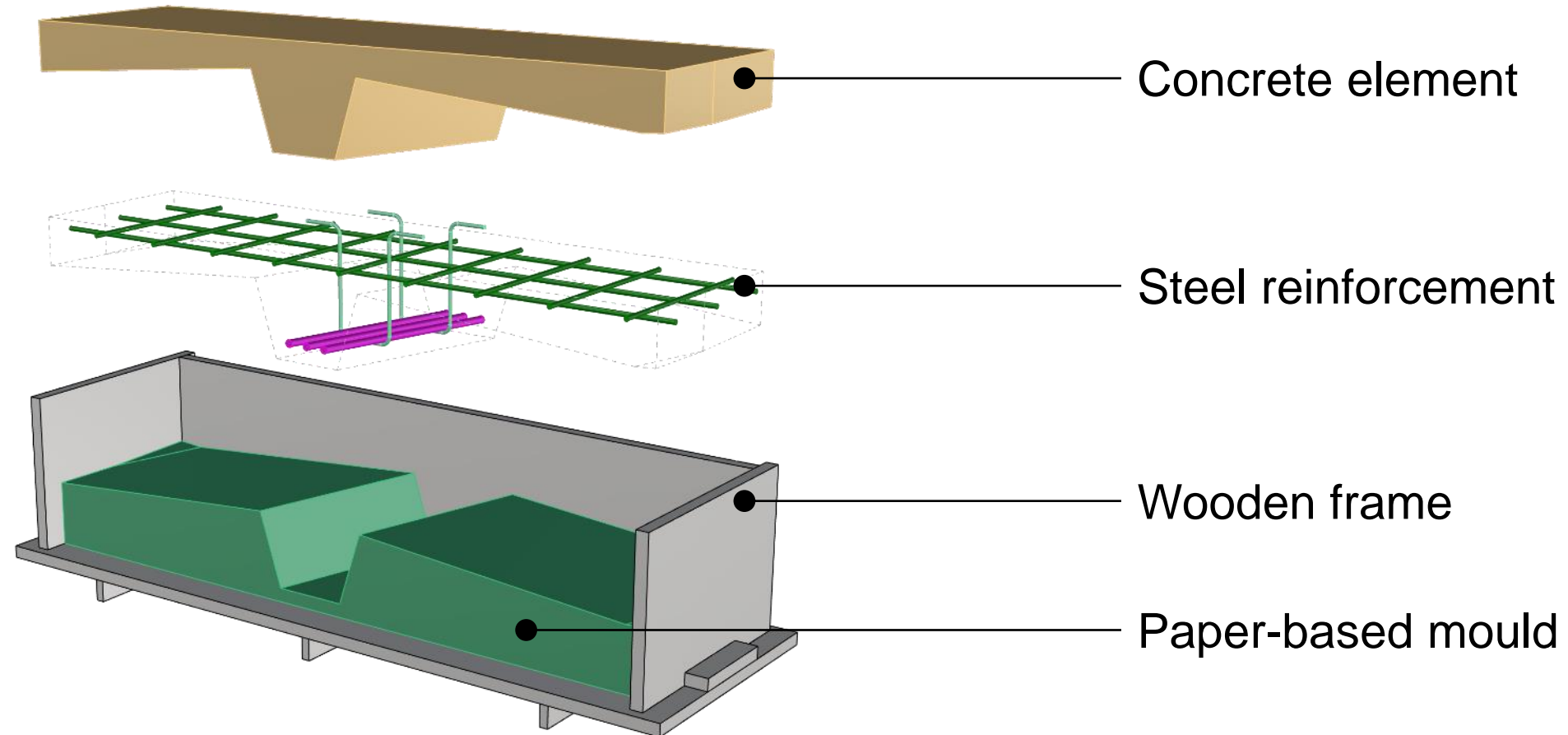


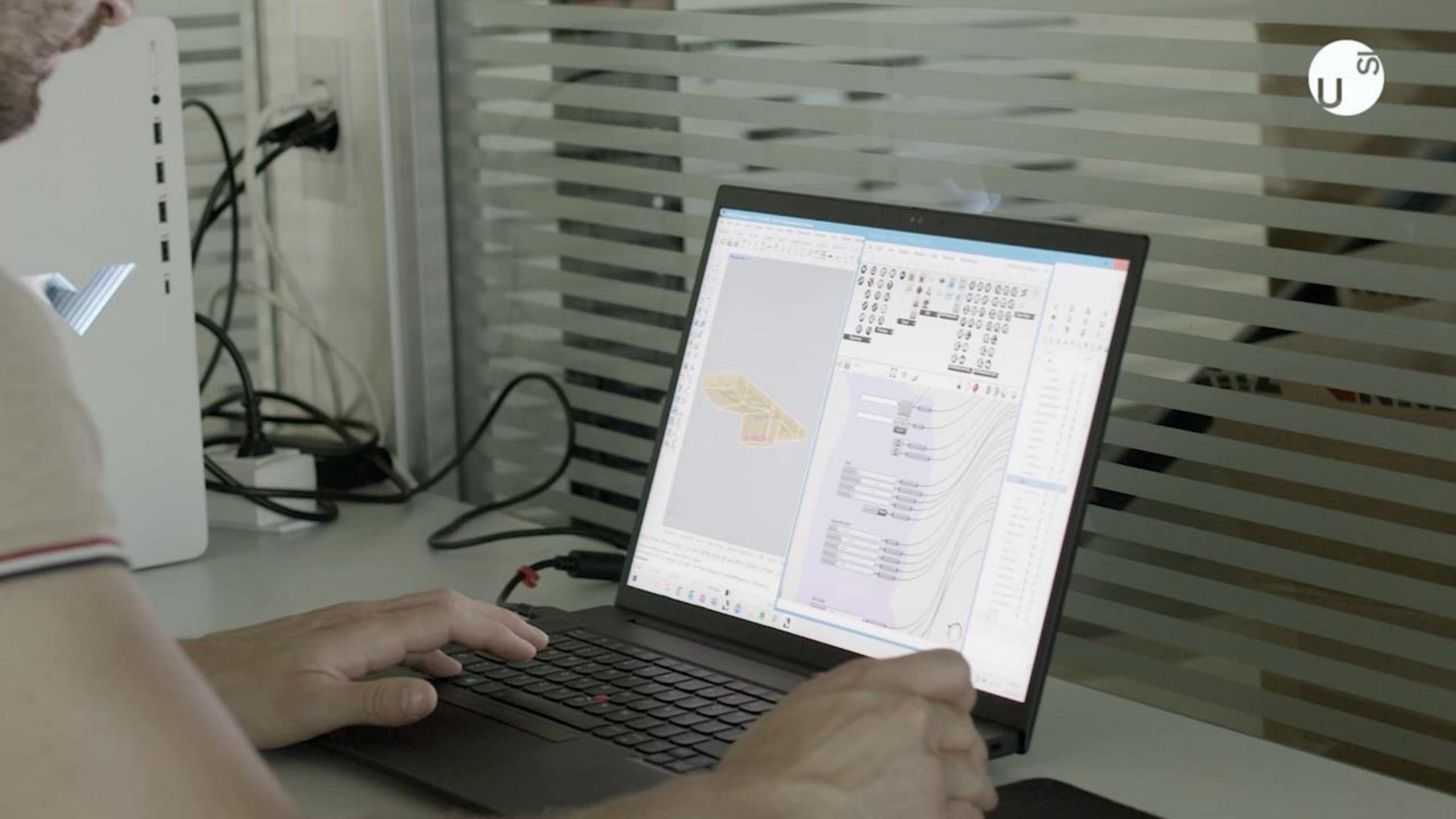
Paper based moulds




- ✓ **Customized design**
- ✓ **50% less concrete**
- ✓ **Low-cost & recyclable**

Standard reinforcement







**PRIME TOWER ZURICH / 40 floors ~ 395,000 m³ concrete
= 39'500Tons of CO₂**

Reduce 50%

Team



Fabio Amicarelli

*Co-founder
Technology and product*

Architect and Doctoral Researcher at the Academy of architecture in Mendrisio.



Prof. Dr. Ena Lloret-Fritschi

*Co-founder
Research and development*

Architect and Assistant Professor at the Academy of architecture in Mendrisio.



Andrea Realini

*Co-founder
Business & finance*

Entrepreneur with 10+ years of experience in the construction market.



Elia Quadranti

Structural engineer

Structural engineer specialized in digital construction and concrete structures.

40+ years of combined experience in the construction sector.





FoldCrete*, FMAA, AAM USI, Fabio Amicarelli 2022





Foldcast

Less concrete, more design.


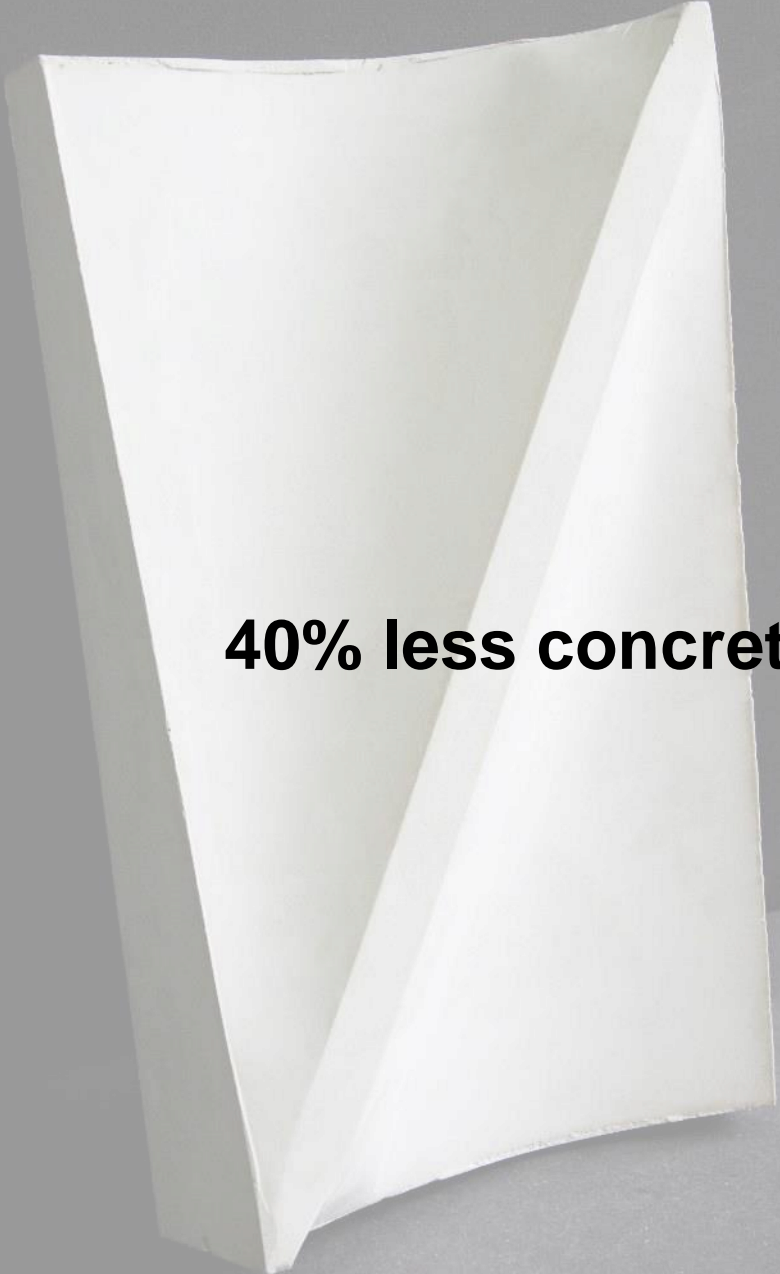


Fabio Amicarelli
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Thanks for Your Attention

Prof. Dr. Ena Lloret Fritschi

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40% less concrete - compared to a standard solid flat slab

Architectural Application

Digital Casting Systems w. standard and ultra-thin formworks



Digital Casting Systems, PCBM, GKR, ETH & FMAA, USI



IfB
Institut für Baustoffe
Institute for Building Materials

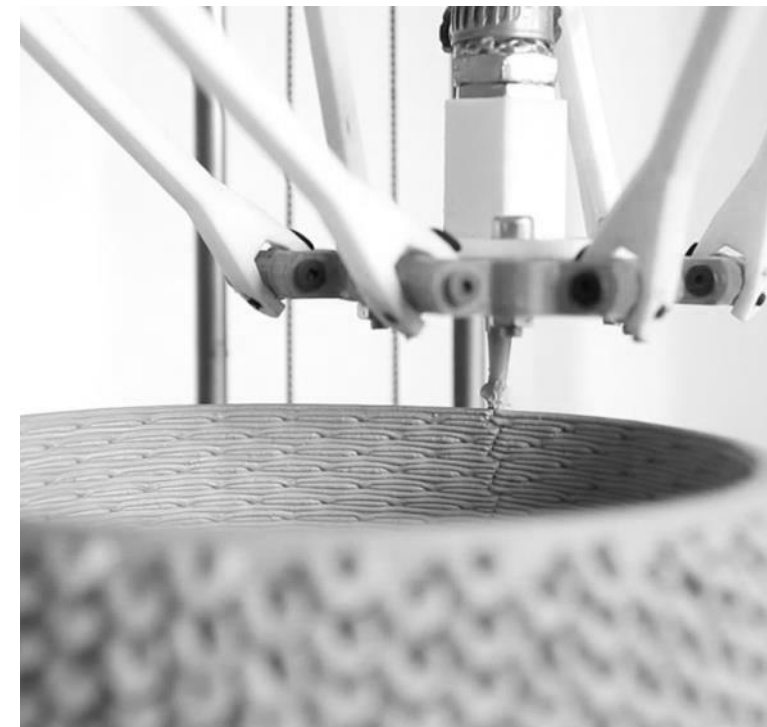
Stay-in-place formworks



AeroCrete, GKR , 2018



Printed formworks (clay, earth, polymer)



Earth-to-Earth



Fabrication and Material Aware Architecture Lab (FMAA)

Prof. Dr. Ena Lloret-Fritschi

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Post. Doc. Selen Ercan-Jenny



Dr. Candidate Fabio Amicarelli



Dr. Candidate Sacha Cutajar



Research Assistant Fen Chan



Research Assistant Wei Ting Chen

Process

