Universität Stuttgart

IntCDC

RP 1-2

PIs

Prof. Lucio Blandini
Institute for Lightweight Structures and Conceptual Design (ILEK)

Prof. Harald Garrecht
Institute for Construction Materials (IWB)

Prof. Oliver Sawodny
Institute for System Dynamics (ISYS)

RP 1-2: “Functionally Graded Concrete Building System – Design, Optimisation, Digital Production and Reuse”

MOTIVATION AND GOALS

Reduce, Reuse and Recycling

- Further reducing GHG emissions, resource consumption and waste volume through circular construction principles [1]

Extension of digital design methods

- Enhancing Co-Design by automatizing the design-to-production interface and establishing an integrative design tool

Digital manufacturing process

- Optimized robotic casting system for precise fabrication

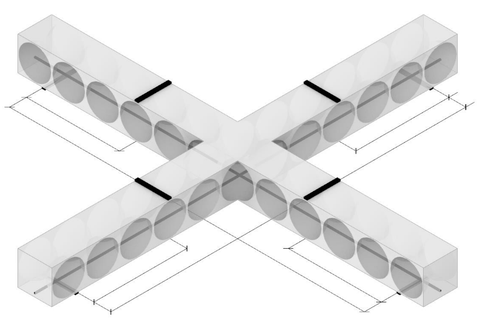
REPORT AND STATE OF THE ART

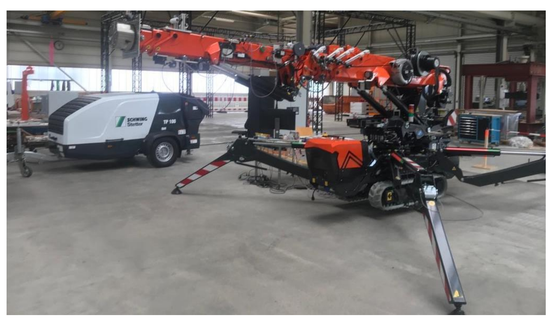
Functionally graded concrete (FGC) elements

- Gradation layout and design of biaxially stressed plates [2], [3]
- Demountable, punctual connections using implants [4]

Fabrication process

- Modelling of the conveyor dynamics [5]
- Methods for synchronized trajectory generation [6]





WORK PROGRAM

1. Reusable functionally graded concrete (FGC) slab segments

- Structural concept and design methods for a reusable FGC slab system with high geometric adaptability, repeatability, reusability and material efficiency
- Conceptualization and validation of demountable, linear joints

2. Extension of digital Co-Design methods for FGC slabs

- Integration of holistic quality data, evaluation of code compliance and the fabrication process into the design process

3. Optimized Digital Casting and Planning for FGC components

- Improvement of the prototypical production system by increased focus on modelling of the flow dynamics and effort on including sensory information, as well as online synchronized trajectory generation

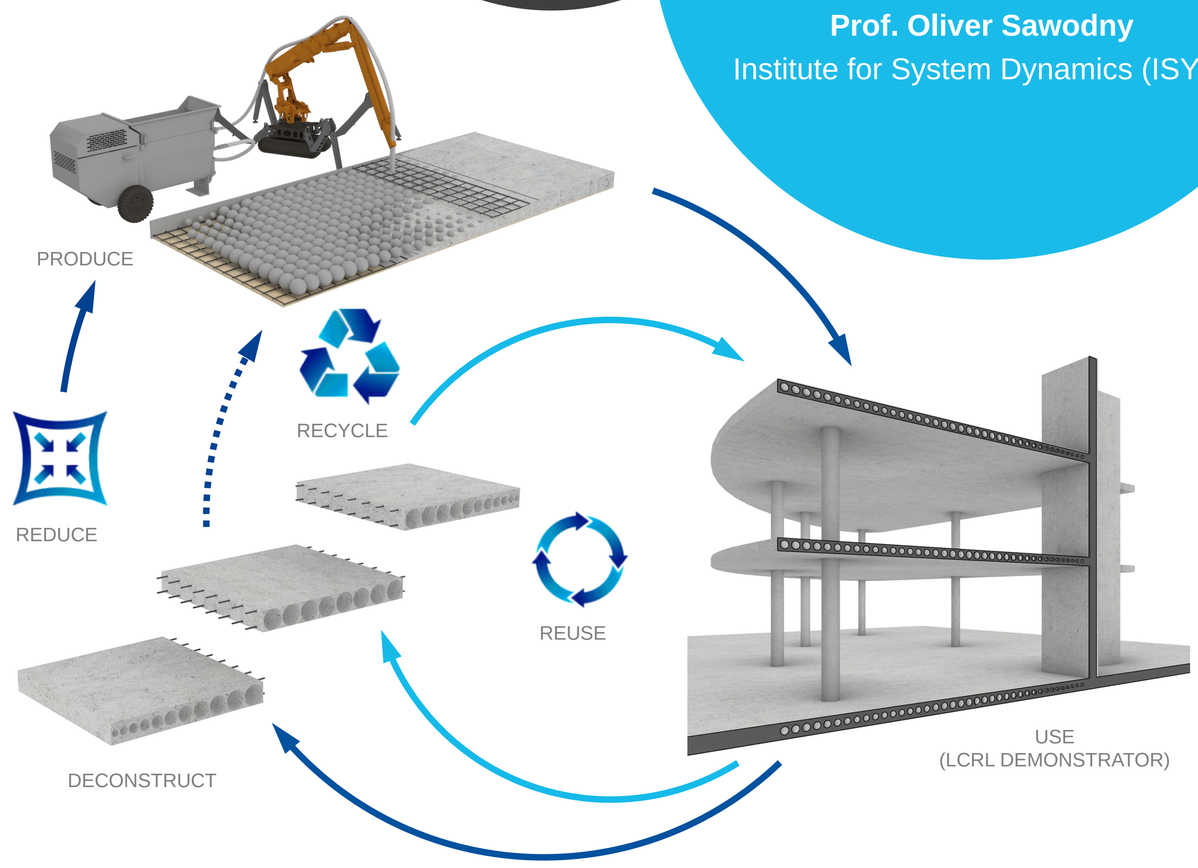
4. Digital Fabrication of Eco-Concrete

- Implementation and usage of real-time feedback in the digital fabrication processes for newly developed eco-concrete mixture

5. Validation of fabrication methods and structural behavior

- Application of the results from WP1-4 on a full-scale concrete slab

ILEK 1,0 PhD		ISYS 0,5 PhD	IWB 1,0 PhD
Design for reuse	**Digital Co-Design**	**Digital fabrication**	
WP 1.1 Structural concept of reusable FGC slab system	**WP 2.1** Extension of digital design methods	**WP 3.1** Optimization and Modelling of the Concrete Casting System	**WP 4.1** Mix-Design for Eco-Concrete
WP 1.2 Design methods for reusable FGC slab segments		**WP 3.2** Synchronized Trajectory Generation for On-Site production	**WP 4.2** Implementation of innovative Real Time Measurement System
WP 1.3 Design and validation of demountable joints for reusable FGC slab system	**WP 2.2** Fabrication interface and feedback loop		**WP 4.3** Mixer-specific Benchmark
WP 5 Validation of fabrication methods and structural behavior on a full-scale concrete slab			



Reduce, recycle and reuse as key principles of circular construction;
Digital manufacturing by aid of an optimized robotic casting system

ROLE WITHIN THE CLUSTER

Co-Design Group / Research Network

- Co-Design of digitally fabricated concrete building systems
- RN I – Multi-Story Buildings – Design, Material and Fabrication of slabs permitting to reduce the environmental impact of concrete
- RN III – Existing Building Stock Extension – Future Adaptability

Demonstrators

- Full-scale reusable concrete slab in cooperation with RP 22-1
- Continuous scientific support to LCRL building demonstrator

Cooperation in the Cluster / Research Project Areas

- RP 8-2 / RP 16-2 – Methods and algorithms
- RP 18-2 – Ecological assessment, quality assurance [7]
- RP 22-1 – Design process, digital casting and positioning of hollow bodies, joint demonstrator
- RPA B.1 - Material System and Process Technology
- RPA B.2 - Methods on conveyor modelling & trajectory generation
- RPA C - Design methods for (reusable) FGC slab elements

from	Expected Co-Design Inputs and Outputs	to
RP 8-2	Camera system for localization of formwork and on-site position calibration	
RP 16-2	Control access to the minicrane	
RP 18-2	Methods for quality assurance of technical quality	
	Accompanying LCA of developed process-steps	
	Evaluation of economic quality resulting from design and fabrication	
	Evaluation of social implications resulting from design and fabrication	
RP 22-1	Data structure and fabrication restrictions for the positioning of hollow bodies	
	Gripping system for the fabrication of a full-scale concrete slab	
	Requirements for the tower-crane gripper	RP 8-2
	Casting system design for mounting on the minicrane	RP 16-2
	Fabrication, material, and component data of graded concrete parts	RP 18-2
	Automated generation of position of hollow bodies for the gripping system	RP 22-1
	Digital casting system for automated fabrication of graded concrete components	

Cooperation within the cluster

PUBLICATIONS

[1] L. Blandini, “Lightweight and Sustainable Concrete Structures: The ILEK Research Strategy,” in fib International Congress 2022 Oslo, 2022.

[2] D. Nigl, O. Gericke, L. Blandini et al., “Numerical Investigations on the Biaxial Load-Bearing Behaviour of Graded Concrete Slabs,” in fib International Congress 2022 Oslo, 2022.

[3] O. Miller, O. Gericke, D. Nigl et al., “Simulation based investigations on the load-bearing behavior of graded concrete components exposed to fire,” Fire, 2022. [Submitted for Review]

[4] O. Gericke, L. Blandini and W. Sobek, “Rigid Implant Connections for Thin-Walled Concrete Beams,” in fib International Congress 2022 Oslo, 2022 .

[5] B. Blagojevic, A. Nitsche and O. Sawodny, “Modeling of transient incompressible concrete mass flow through a hose,” in 2021 IEEE Conference on Control Technology and Applications (CCTA), 2021, pp. 424–429, doi: 10.1109/CCTA48906.2021.9659068.

[6] B. Blagojevic, B. Schönemann, D. Nigl, L. Blandini and O. Sawodny, “Trajectory Planning for Concrete Element Fabrication with Optimal Control,” in IECON 2021 – 47th Annual Conference of the IEEE Industrial Electronics Society, 2021, pp. 1–6, doi: 10.1109/IECON48115.2021.9589695.

[7] Y. Yang, L. Balangé, O. Gericke, D. Schmeer, L. Zhang, W. Sobek and V. Schwieger, “Monitoring of the production process of graded concrete component using terrestrial laser scanning,” Remote Sensing, vol. 13, no. 1622, 2021, doi: 10.18419/opus-11455.