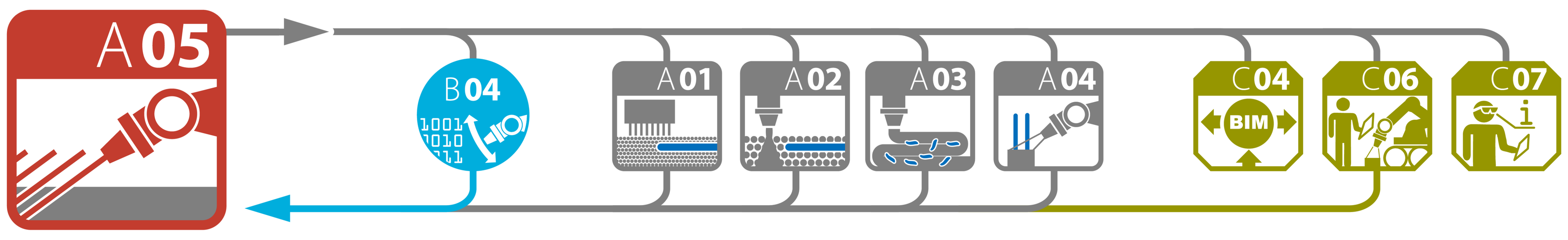
A 05

Integration of Individualized Prefabricated Fibre Reinforcement in Additive Manufacturing with Concrete

Jun.-Prof. Dr. sc. ETH Norman Hack
Prof. Dr.-Ing. Christian Hühne

Junior Professorship for Digital Building Fabrication, Institute of Structural Design, TUBS
Institute for Adaptronics and Function Integration, TUBS

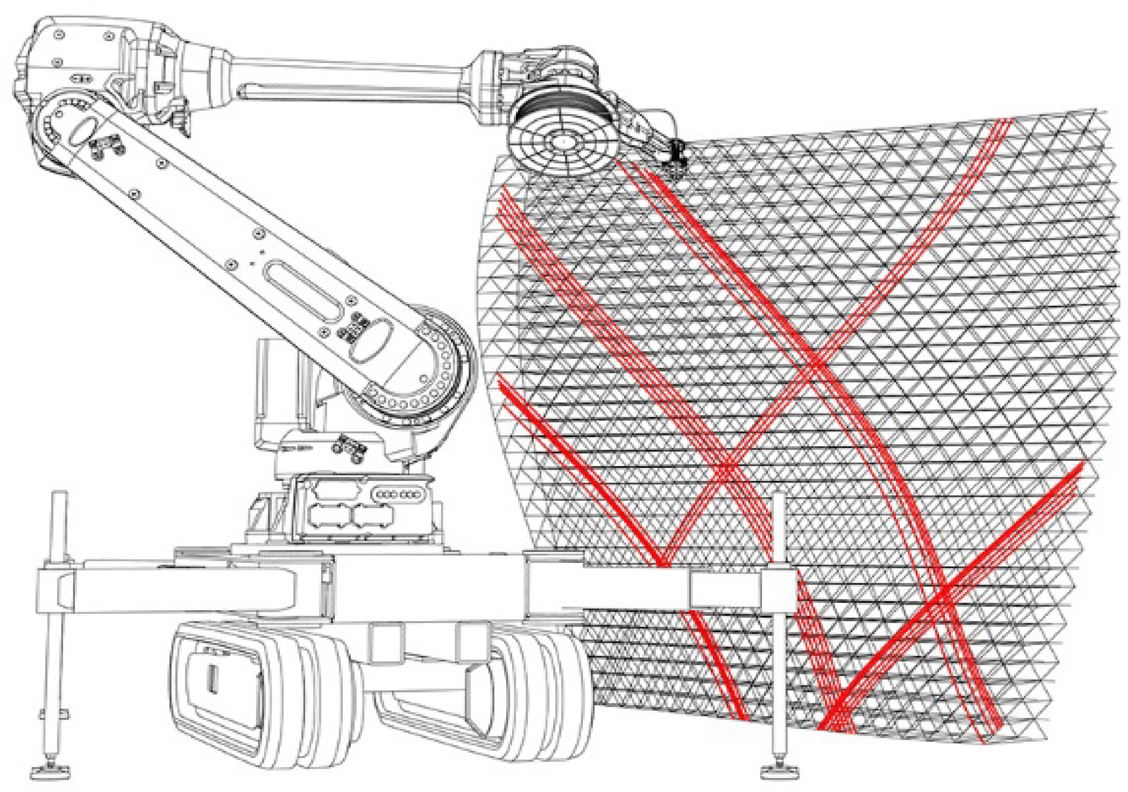
Summary



One of the biggest challenges in 3D printing with cementitious materials is the integration of reinforcement. As 3D-printed, unreinforced concrete components can only compensate for limited tensile forces, their range of applications is confined to predominantly compression-stressed components and thus the structural potential of 3D-printed parts remains unrealized. The aim of this project is to develop textile-based reinforcement strategies for additive manufacturing with concrete and to utilize the advantages of textile reinforcement (e.g. corrosion resistance and material flexibility) for the production of material-efficient, individualized structures.

Project Aims

- Continuous process chain for robot-based production of prefabricated fibre reinforcements and additive concrete manufacturing technology
- Applicability of these combinations for building components
- Methods of design and techniques for production of prefabricated fibre reinforcement for the three main additive manufacturing techniques
- Validation of fabrication techniques through physical prototyping and structural testing



Concept for the prefabrication of a fibre mesh.

Concept

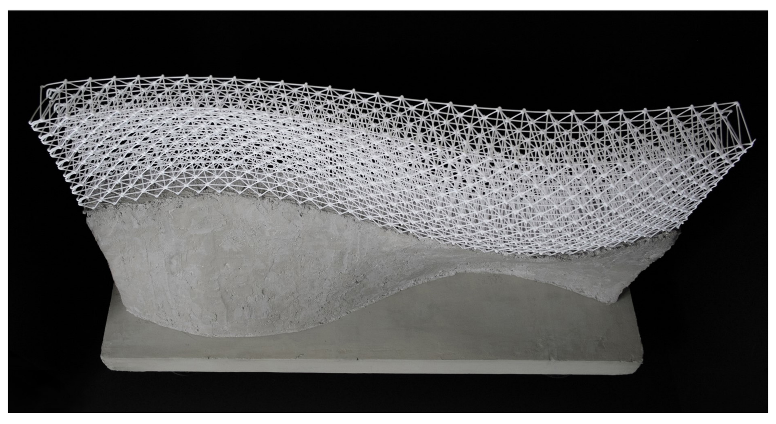
Conceivable fabrication scenario:

- A robot prefabricates a fiber reinforcement cage.
- In a subsequent fabrication step, the robot will print concrete onto the mesh.
- The concrete surface is automatically trowelled, before the concrete has cured.
- The mesh remains inside the structure acting as reinforcement.

Research Questions

- Conceptual design process for the integration of individualized pre-fabricated fibre reinforcement regarding the AM technologies
- Application of the design process to determined building elements
- Computational design strategies for complex building elements
- Prototypical robotic end effector design and realization
- Robotic fabrication of selected mid-scale components
- Material characterization e.g. through pull-out tests
- Influence of concreting process on reinforcement properties
- Development of a fibre winding end effector with multiple spools, core and spiral filaments as well as controllable curing ability
- Digital work-flow for automated generation of reinforcement strategies – from rule-based design up to process simulation
- Real-scale demonstrators: preliminary prototypes and volumetric building component

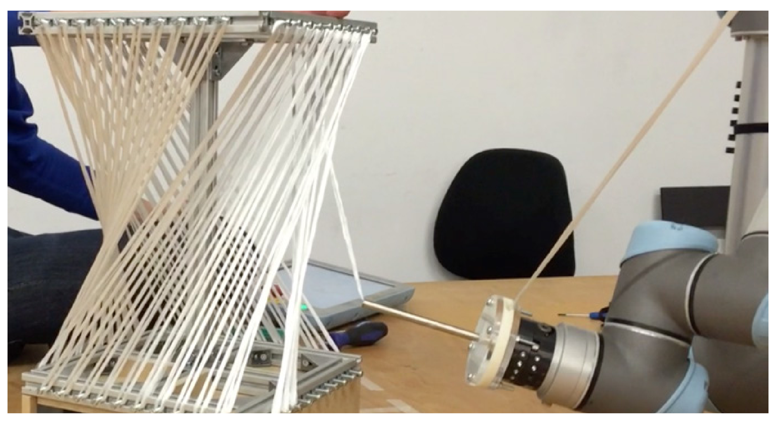
Preliminary Work



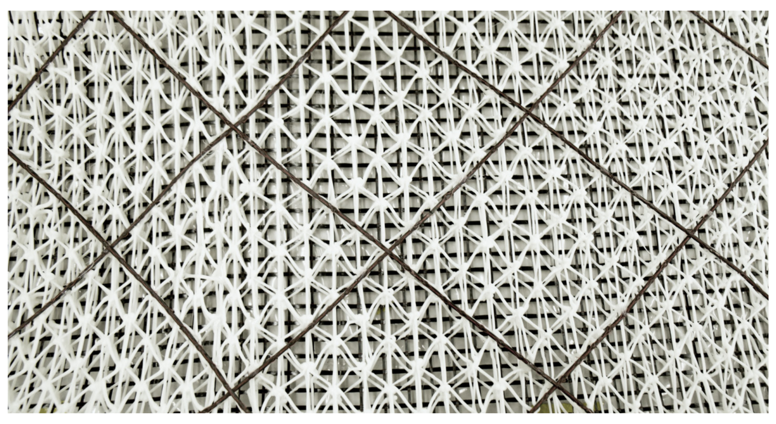
Mesh Mould, Phase 1: Spatially printed mesh, filled with concrete, Gramazio Kohler Research, ETH Zürich

Mesh Mould, Phase 2: In situ fabrication of a steel mesh that acts as reinforcement and formwork.

Mesh Mould, Phase 2: Filling of the mesh by manually „printing" on and into the mesh.

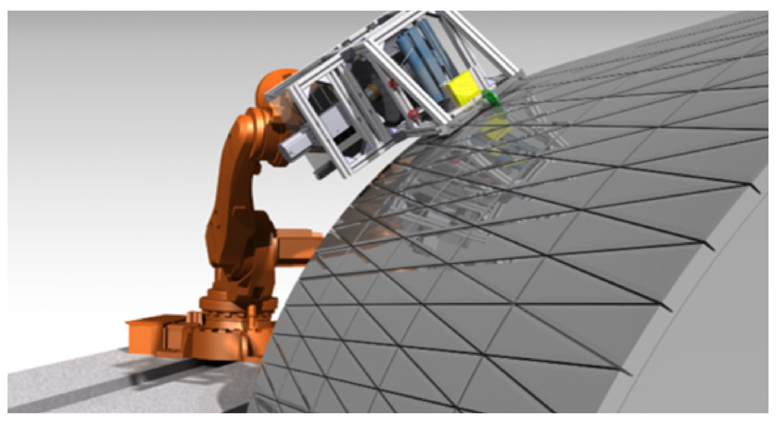


Robotic fibre winding process, developed at the Digital Building Fabrication Studio at ITE, TUBS.



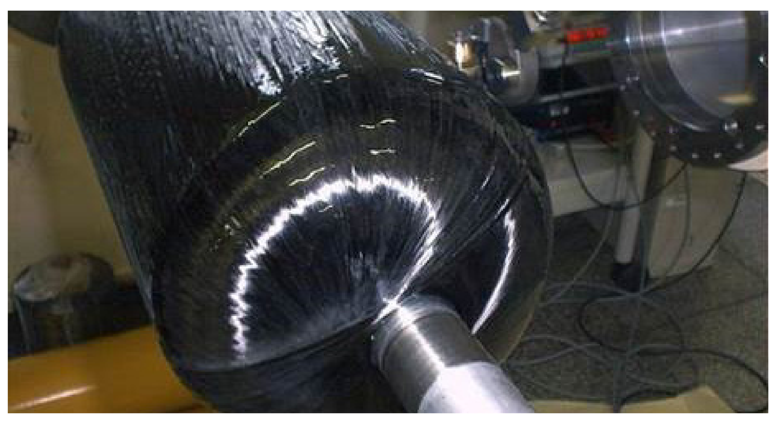
Spatially printed mesh with carbon fibre reinforcements.

Initial test Specimen of a robotically wound stay-in-place formwork.



AFP process for anisogrid, assembly-free composite fuselage from PoLaRBEAR-project, iAF, TUBS

Pulltrusion of glass fiber elements, iAF



Automated fibre winding process, iAF