Additive Manufacturing in Construction

2nd funding period: The Opportunity for Large Impact

AMC TRR277

A05

Integration of Individualized Prefabricated Fibre Reinforcement in Additive Manufacturing with Concrete

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Project aims of 2nd funding period

A05 aims to extend the explorations regarding fibre-based reinforcement methods from off-site fabrication to on-site and in situ fabrication. This leads to the hypothesis that robot-assisted production of fibre reinforcement using the Dynamic Winding Machine is possible which meet the complex requirements of on-site production and for which methods of production-oriented design can be derived.

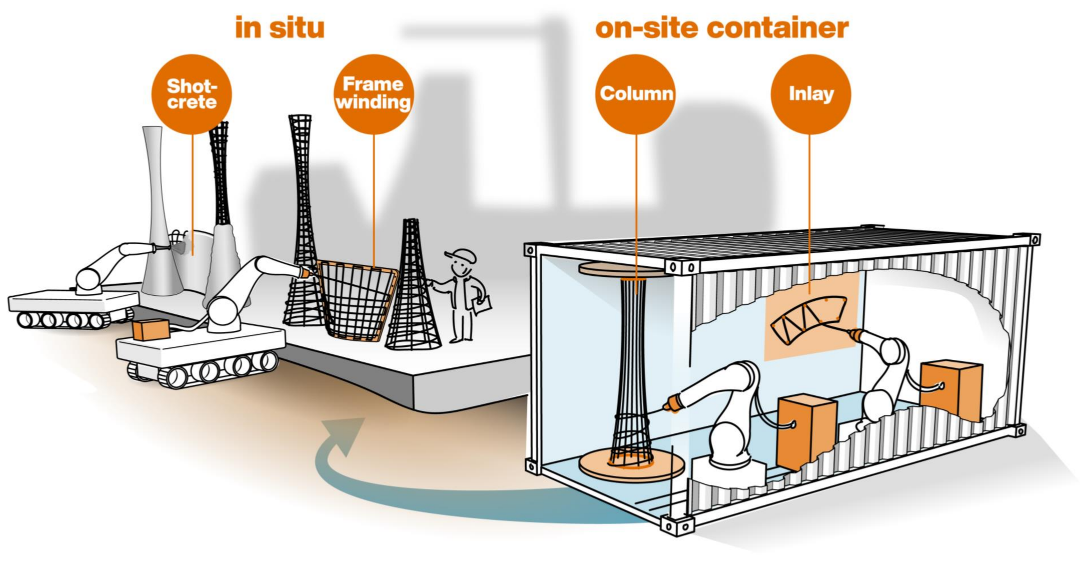
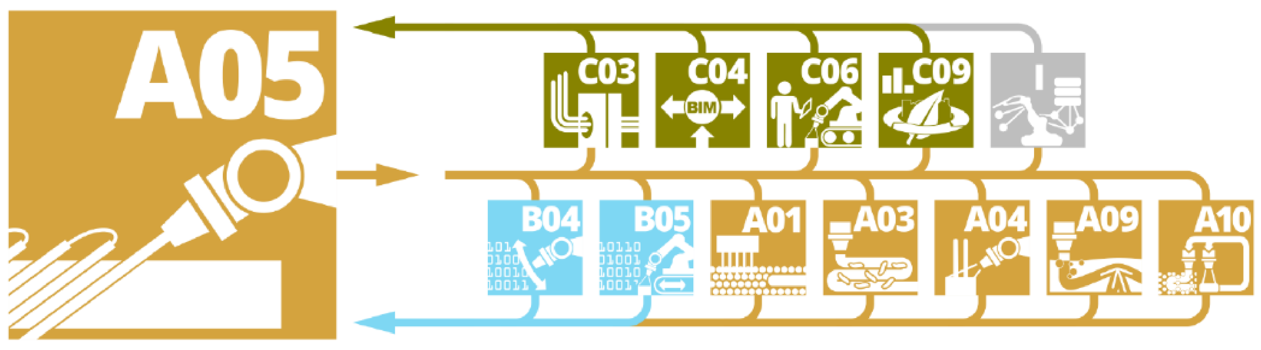


Fig. 1: Concept for on-site and in situ production for fibre-reinforced AM structures

Key collaborations in 2nd funding period



A04: Investigation of reinforcement strategies with Shotcrete 3D Printing
A01: Investigation and testing of A05-produced reinforcement with SCA
B04: Sensing for on-site fabrication
B05: Developing strategies for the usage of mobile robots with the DWM
C03: Integration of heating wires into the winding process
C06: Process and production sensing for on-site fabrication
C09: Evaluation of sustainability criteria

Work programme

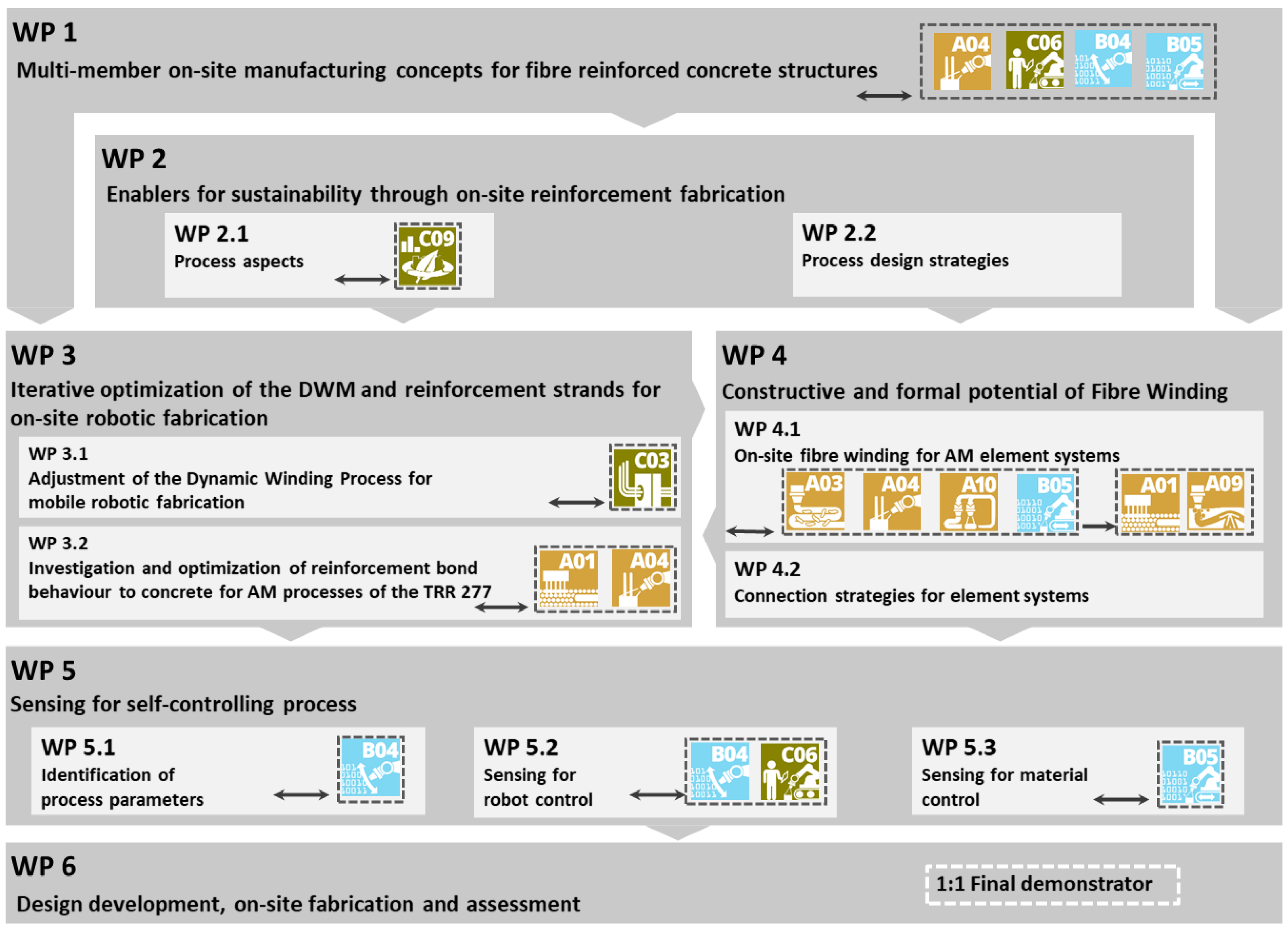


Fig. 2: Work programme flow chart

Content of work

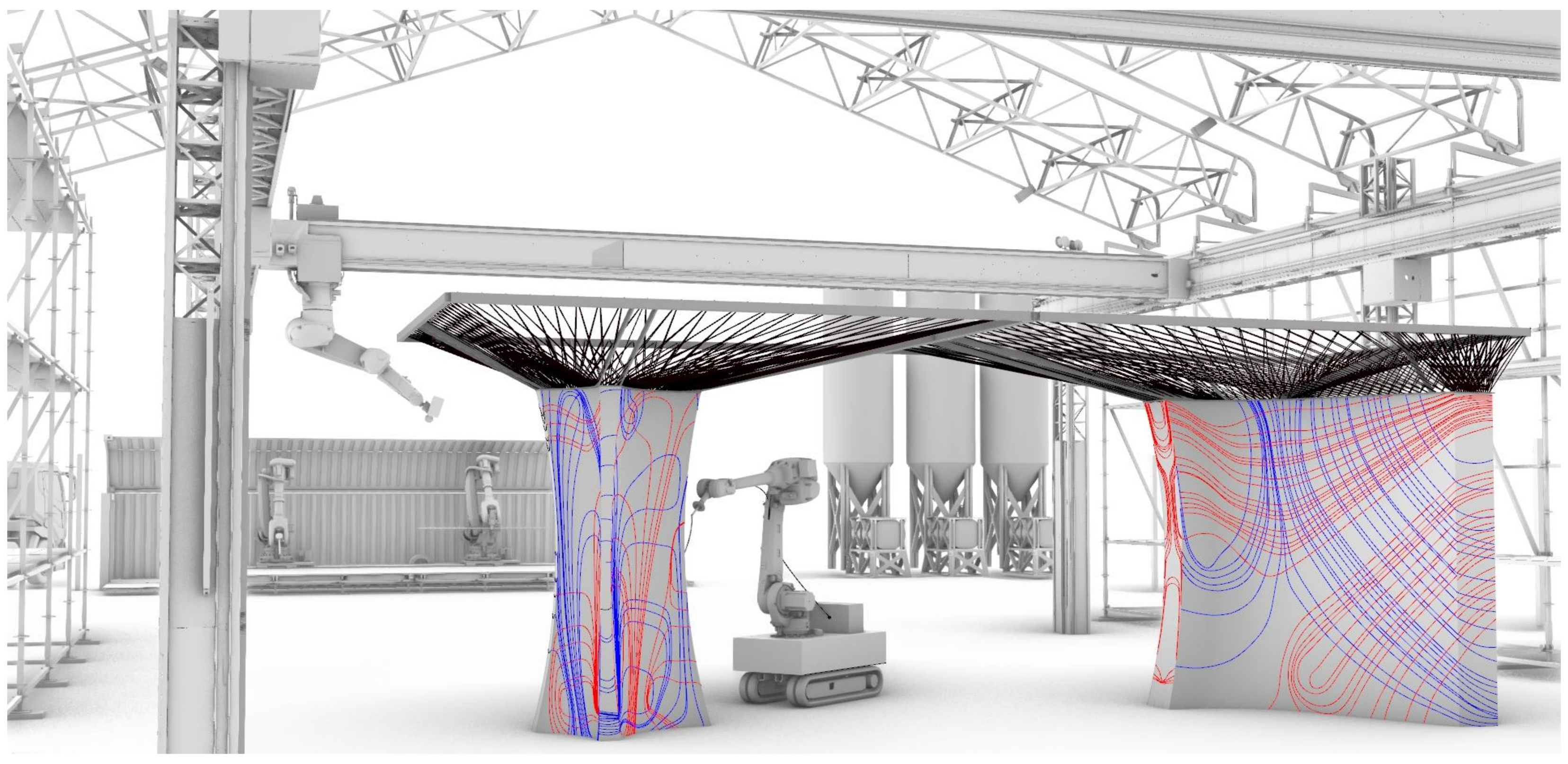


Fig. 5: Concept for the usage of A05-developed processes at the DCS

1: Overall concept:

New on-site manufacturing strategies for fibre-based reinforcement considering size and number of interconnected manufacturing units.

2: Environmental sustainability

Selection of sustainability criteria and evaluation against these criteria comparing on-site and off-site AM procedures.

3: Reinforcement production

Robot-assisted reinforcement production that handles the complexity of fibre diameters, deposit lengths and environmental conditions.

4: Element to element systems

Digital fabrication methods for element systems composed of several tectonic elements.

5: Adaptive manufacturing

Detection of process parameters and control of the manufacturing process through integrated Resonant Ultrasonic Spectroscopy and Fibre Bragg Grating sensor technology.

Final demonstrator

Validation of the developed methods and processes through design and production of an element system at the DCS.

Methods

Fabrication of fibre reinforced elements and element systems

By using the unique infra-structure given by the TRR 277 (e. g. Digital Construction Site (DCS), Mobile Robots, Dynamic Winding Machine, etc.) the realisability of fully additively manufactured, fibre reinforced elements and element systems will be investigated on-site.

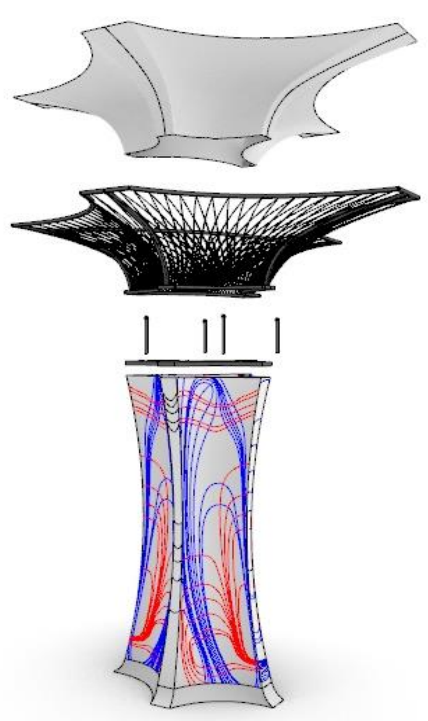


Fig. 3: An system of fibre-winded construction elements

Sensing and testing for process control and material characterization

An assessment of the general feasibility of the proposed concepts and production strategies will be carried out. In order to quantify the process stability and the mechanical performance of the manufactured elements, sensors will be integrated and the gained data will be used to optimise the production process iteratively. Mechanical tests are carried out to quantify the mechanical properties of the reinforcement strands.

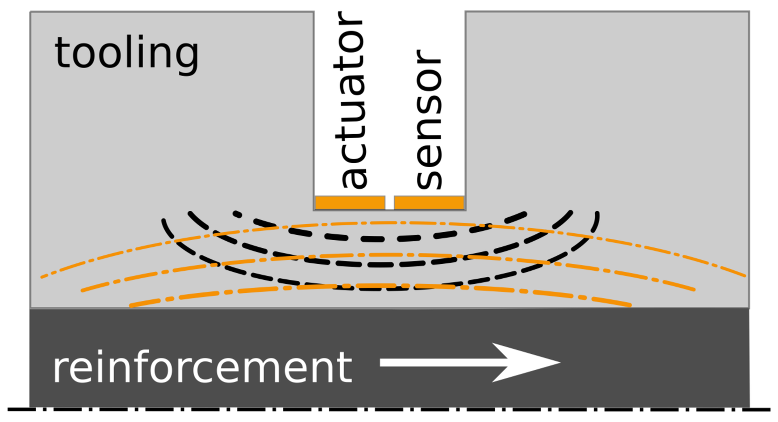


Fig. 4: Schematic functionality of a Resonant Ultrasonic Spectroscopy sensor

Outlook 3rd funding period

- A detailed and production-oriented design of the connection areas of the structural elements will be focused.
- The integration of functionalities to achieve a integrative design will be addressed.
- The robustness of the controlled process will be investigated and artificial intelligence will be used to optimise the process parameters.

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