

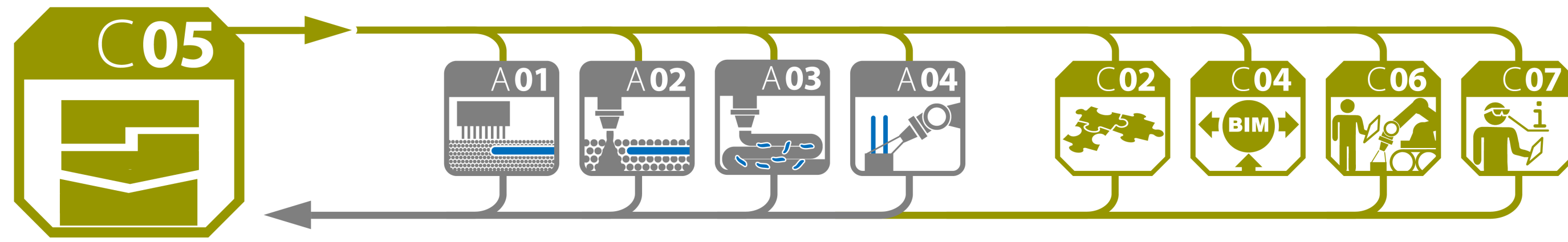


## Joining Principles for Combination of Concrete Elements Produced by Different Additive Manufacturing Processes

Prof. Dr.-Ing Martin Empelmann  
Prof. Dr.-Ing. Harald Kloft

Institute of Building Materials, Concrete Construction and Fire Safety, TUBS  
Institute of Structural Design, TUBS

### Summary



In this project, principal questions on the jointing of additively manufactured (AM) structural components using dry joints will be investigated. Based on the features of three AM processes (particle-bed, extrusion, shotcrete), various joint types (smooth, profiled) and production methods (directly printed, cut, grinded) are considered with regard to joint topology, dimensional accuracy and load-bearing

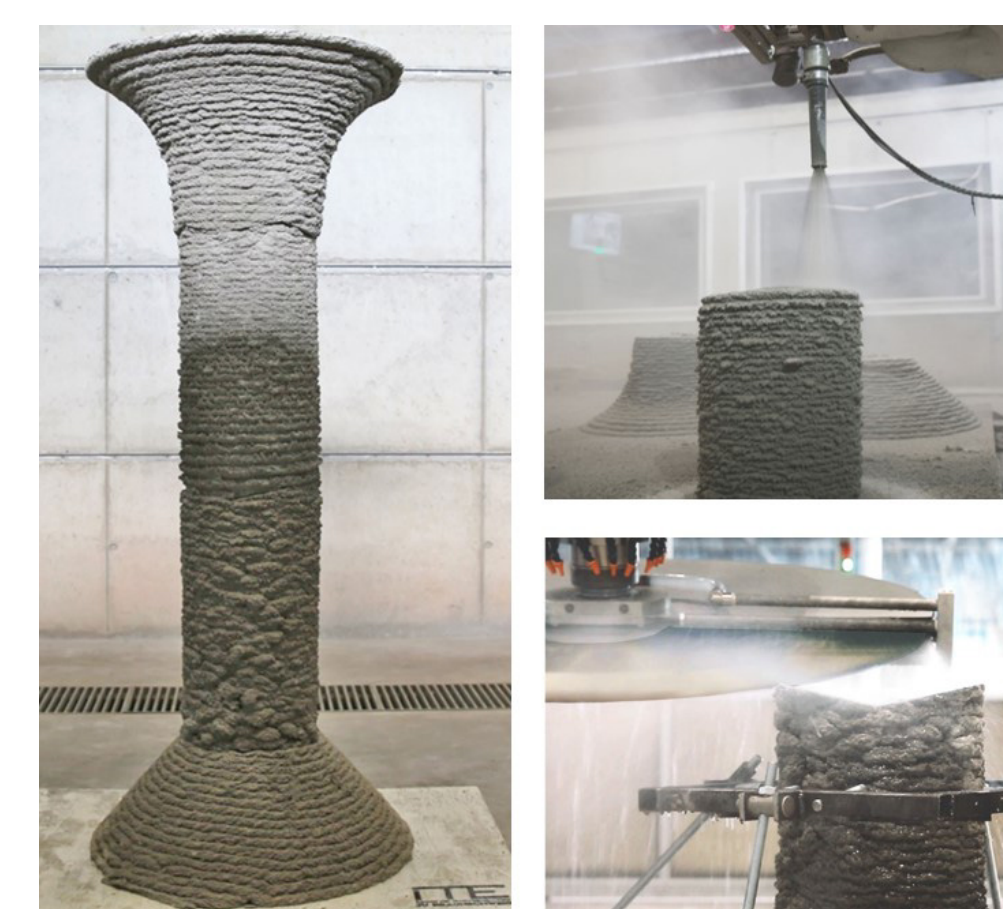
behaviour. The investigation strategy comprises experimental, numerical and theoretical methods and is consecutive in scale (micro, meso) as well as loading type (compression, shear). The results will provide fundamental insight into the load-bearing behaviour of AM dry joints.

### Preliminary Work

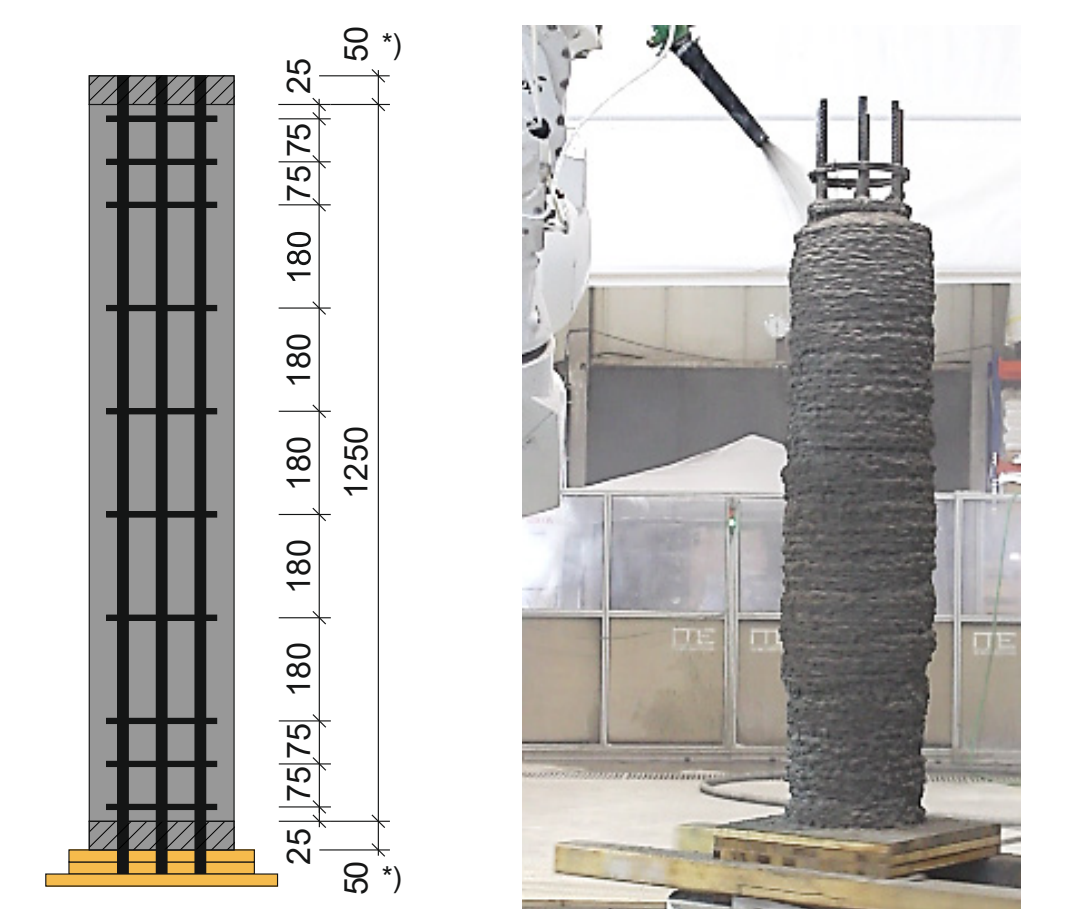
- **PL Martin Empelmann:** DFG Priority Programme 1182 “Sustainable Building with UHPC” (2005-2012); BMWi research project “KoHöMaT” (2013-2016); BMWi research project “ConJack” (2017-2019)
- **PL Harald Kloft:** DFG Priority Programme 1542 “Concrete Light” (2011-2018); NTH research project „Development of a robotic sprayed concrete technology for generative manufacturing of complex concrete structures without formwork“ (2016-2019)
- **PLs Martin Empelmann & Harald Kloft:** Demonstrator “UNI-CON<sup>2</sup>” in DFG Priority Programme 1542 “Concrete Light” (2017); Production of first 3D printed reinforced concrete columns (2019)



UHPC double shear test with a profiled mortar joint



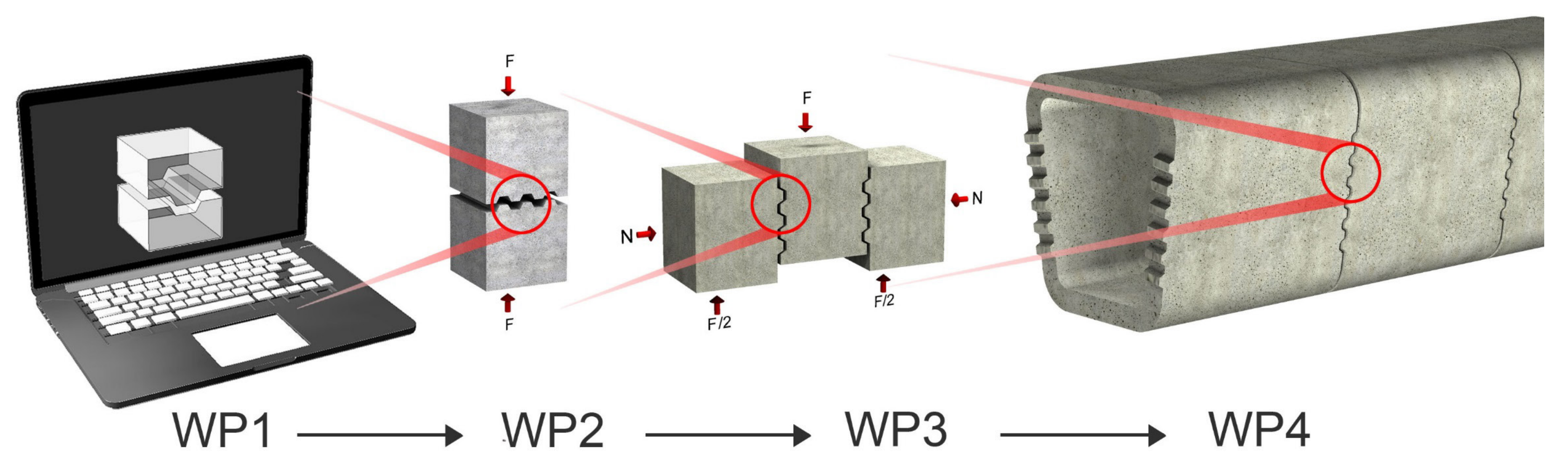
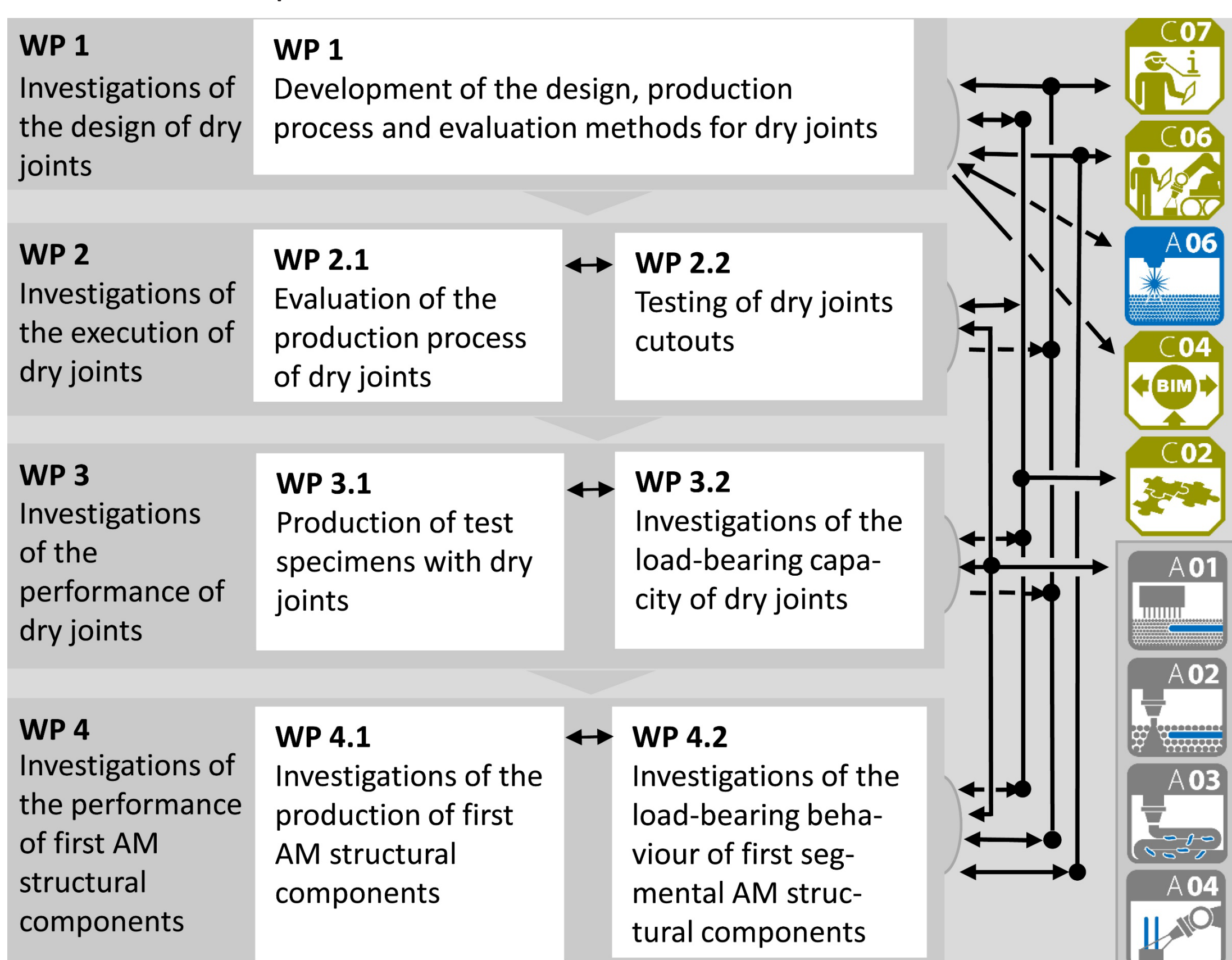
3D-printed and post-processed segmental concrete column



3D-printing of reinforced concrete columns

### Project Aims

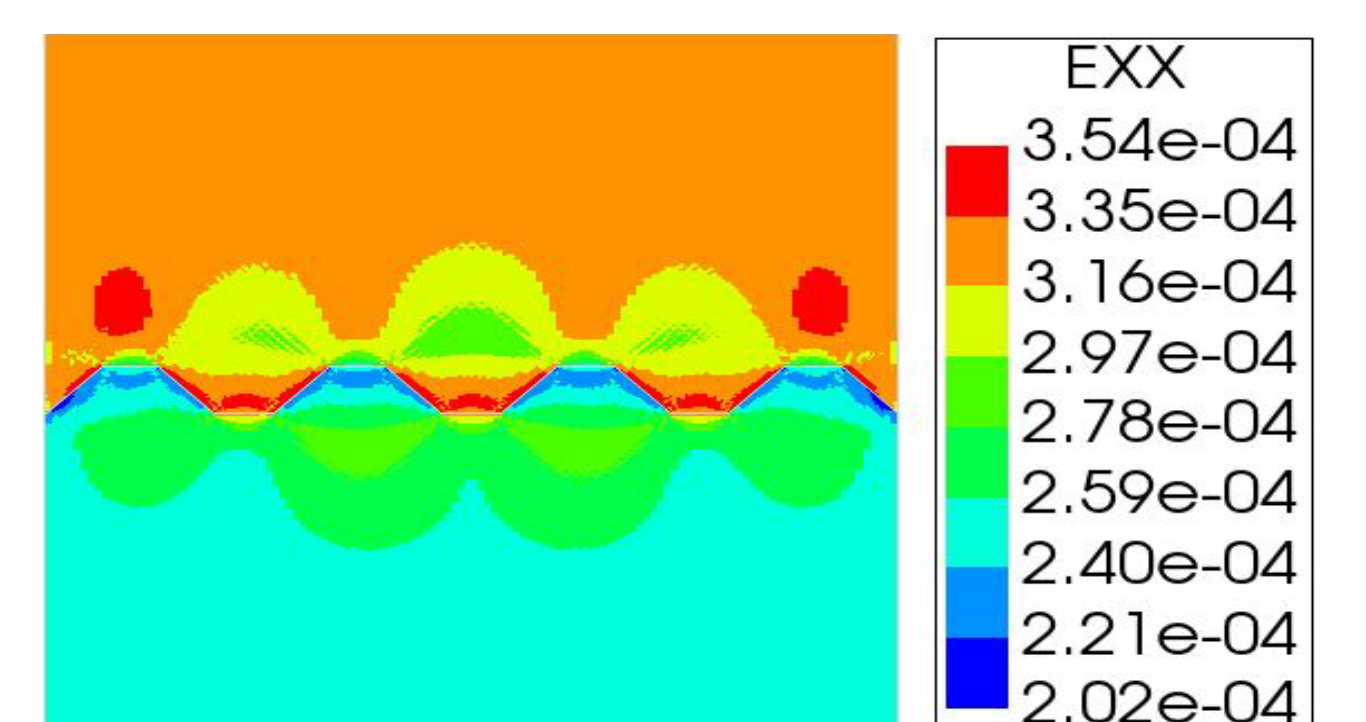
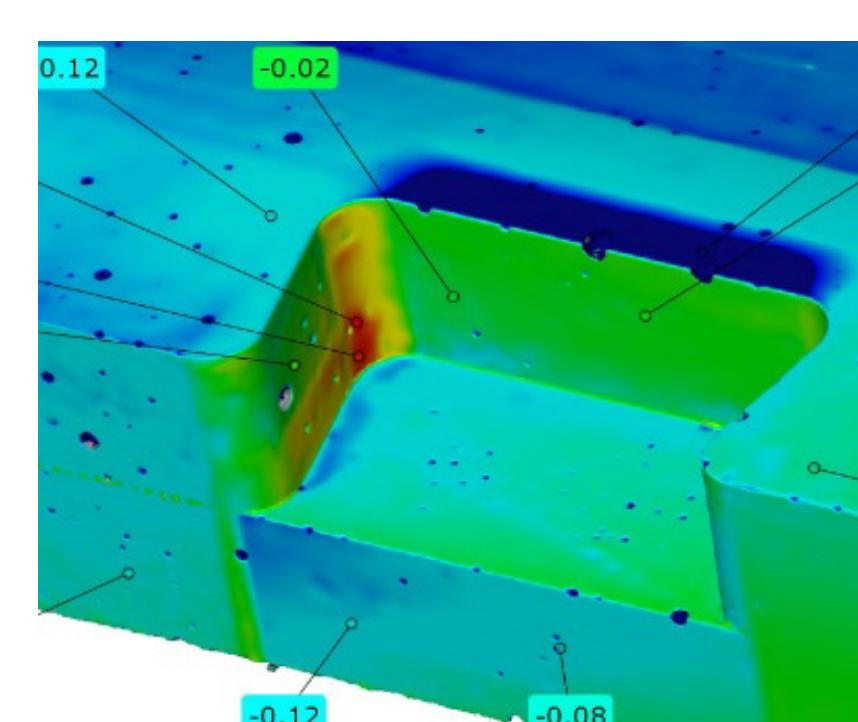
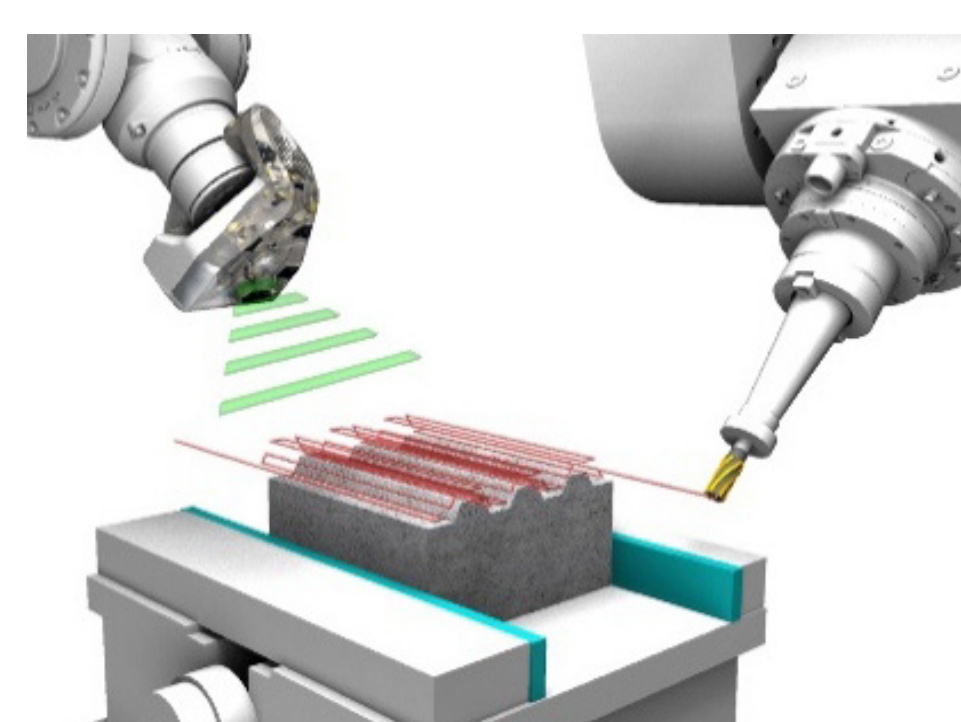
This project aims are to investigate the execution, production process and load-bearing capacity of the joint region of AM concrete segments. To reach this goal, four work packages (WP1 – WP4) with the following milestones are planned:



Overview of the planned work packages (WP) and investigations

### Methods

- Theoretical considerations of suitable joint geometries and production path (printing and subtractive post-processing)
- Experimental investigation of the production of smooth and profiled dry joints
- 3D-scanning of the joints and target-performance comparison with digital tools
- Examination of the dry joints using CT, digital microscope and SEM to detect possible damage caused during the production process
- Numerical compression tests, double shear tests and segmental girder tests
- Numerical investigations (FE analysis) to simulate additional test configurations
- Theoretical evaluations of test results and derivation of a calculation approach



### Role within TRR 277

- C05 is closely linked to projects A01 to A04, which deal with the concrete AM processes.
- The findings of C05 will be integrated into the C projects C02, C04, C06 and C07.
- An exchange with A06 is planned to initiate connections between AM steel elements and AM concrete elements for future funding periods.