Additive Manufacturing in Construction
1st funding period: The Challenge of Large Scale

AMC TRR277

A03

Extrusion of Near-Nozzle Mixed Concrete – Individually Graded in Density and in Rate of 3D Fibre Reinforcement

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Project summary

Conventional extrusion-based 3D concrete printing (E3DCP) is limited by the inevitable trade-off between pumpability and buildability. The Near-Nozzle-Mixing (NNM) process eliminates this obstacle by drastically reducing the transport distance. This allows the development of a new generation of high performance and sustainable materials for E3DCP. The objective of this project is to create a working prototype, analyse and optimise its process parameters, and develop a variety of NNM printable materials.

Key collaborations in 1st funding period

- A02: **Development** and **evaluation** of suitable material and their measuring methods for 3DCP
- B05: Exchange of **material and process** knowledge. Development of novel outside powered extruder for mobile robots.
- C03: Proven **that simulation- and functional integration techniques** of C03 are applicable in extrusion processes (Demonstrator)
- C04: Proven that adaptive **path planning** is applicable for extrusion processes

Main outcome in 1st funding period

- Novel Near-Nozzle-Mixing (NNM) process
- Operable end effector with optimized parameter sets
- Broad range of new, NNM-printable materials:
  - Light-weight mortar (LWM)
  - Natural sand-based mortar (SBM)
  - Recycled aggregate mortar (RAM)
- First graded objects successfully printed

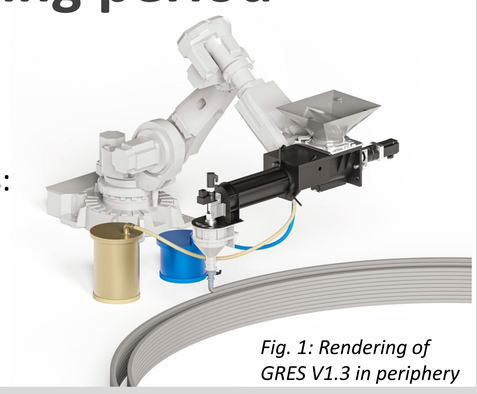


Fig. 1: Rendering of GRES V1.3 in periphery

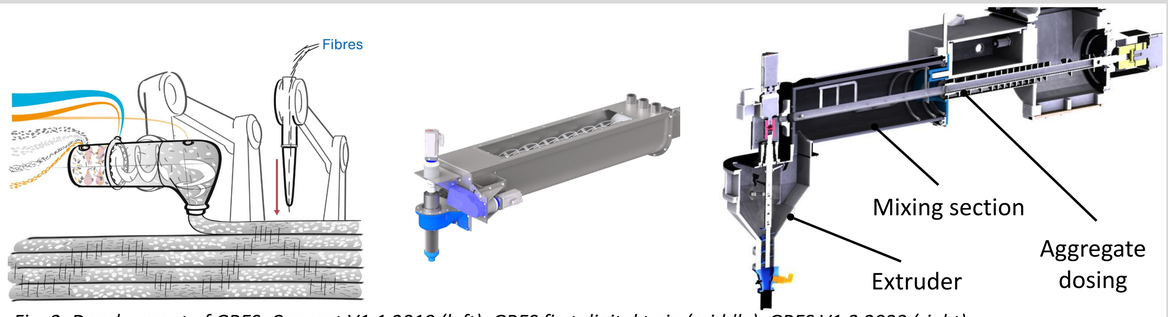


Fig. 2: Development of GRES: Concept V1.1 2019 (left), GRES first digital twin (middle), GRES V1.3 2023 (right)

Project status

Essentials

- Full online control
- Online material property manipulation
- Material switch / gradation
- Complete data set for parametric studies and process analysis

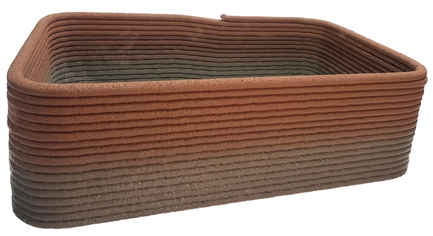


Fig. 3: First graded wall section produced by GRES V2 bottom layers SBM top layers LWM

Fig. 4: V1 of NNM 3D printed chair made with trial waste material

System and Process

- 2 prototypes:
  - GRES V1.2 (static/dynamic): Compound
  - GRES V1.3 (dynamic): Aggregate and paste
- Digital twin CAD-Models
- Modular mixing- and compression shaft
- Periphery compatible with other robots
- Critical dead zones in GRES V1 identified

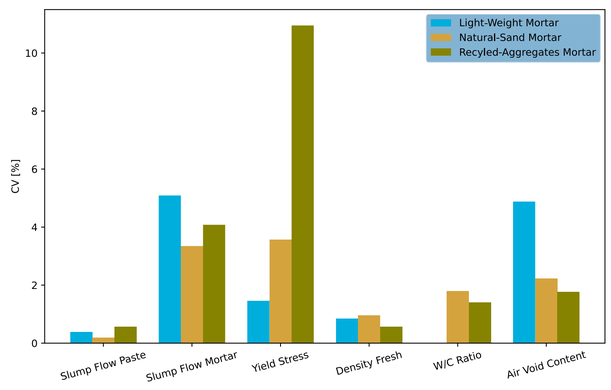
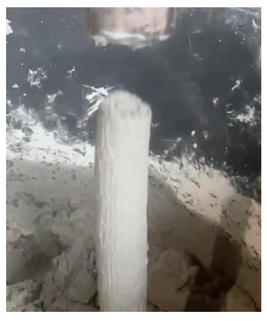


Fig. 5: Coefficient of variation for mortar materials

Material design

- Suitable recipes for the novel process design with highly diverse material properties for specific purposes
  -> LWM, SBM, RAM
- Identified appropriate material tests for evaluating material properties
- High material buildability
- Identified existing gaps that need to be addressed



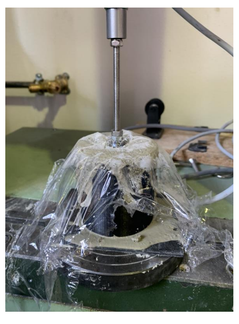


Fig. 6: Slug test with GRES V1.3 (left), slow penetration test (right)

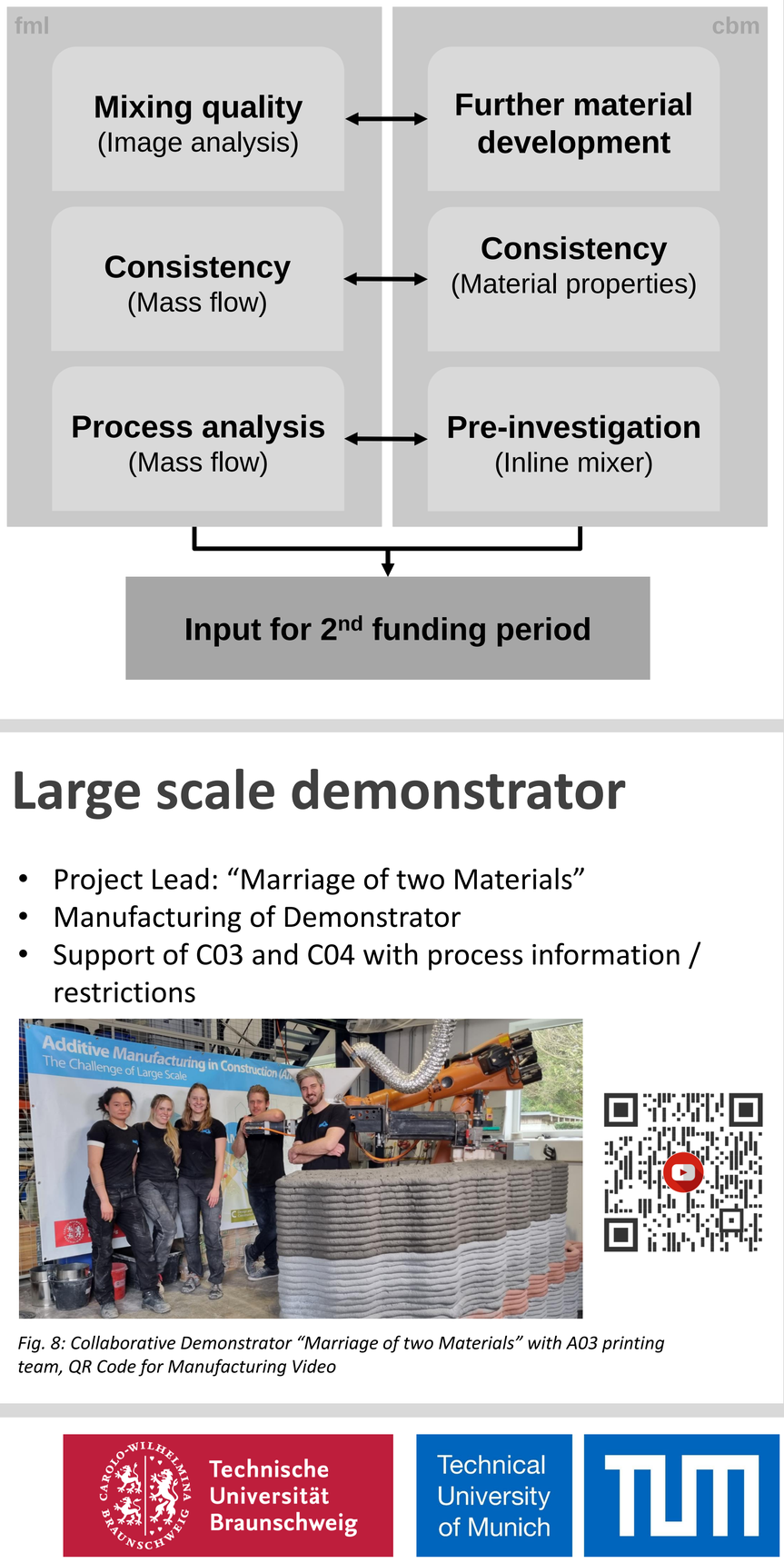
Challenges

- Individual constituent mixing (micro dosing)
- Automatic material feeding (vibration unsuitable)
- Rebar insertion
- Continuous paste mixing mandatory
- More interdisciplinary than initially predicted

Fig. 7: Collapsed 7 tip column due to overhang tests

Until end of 1st funding period

Data will be collected in several critical areas, to ensure an efficient start of the 2nd funding period.



Large scale demonstrator

- Project Lead: “Marriage of two Materials”
- Manufacturing of Demonstrator
- Support of C03 and C04 with process information / restrictions

Fig. 8: Collaborative Demonstrator “Marriage of two Materials” with A03 printing team, QR Code for Manufacturing Video

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