AMC TRR277

A01

Particle-Bed 3D Printing by Selective Cement Activation (SCA) - Particle Surface Functionalization, Particle-Bed Compaction and Reinforcement Implementation

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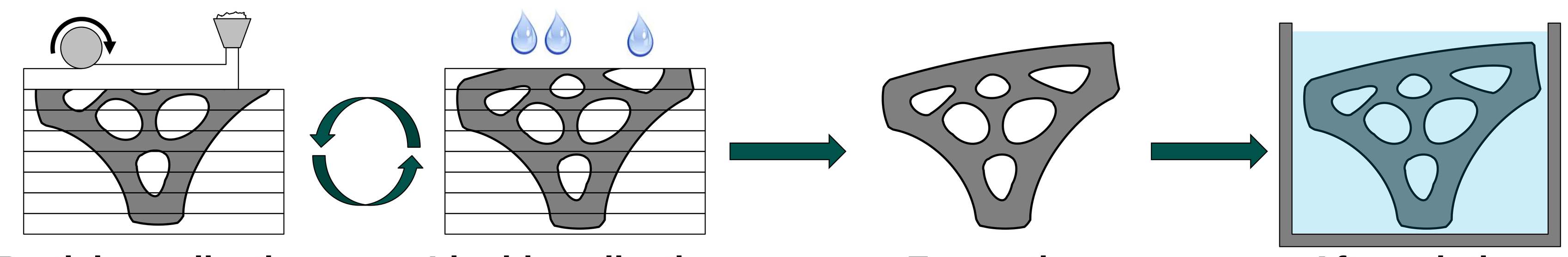
Project summary

This project focusses on high-resolution particle-bed 3D printing of reinforced cementitious composites by Selective Cement Activation. To understand the governing mechanisms affecting the material-process interaction, basic interdisciplinary research is conducted.

Workflow



Main outcome of 1st funding period

Particle functionalization & compaction
- Particle-bed packing density highly effects the compressive strength
- Packing density can be increased by particle functionalization and compaction

Liquid application and intrusion
- Water application as a jet increases layer bonding and mechanical strength compared to the application as a droplet
- A model for the liquid intrusion based on the Young-Laplace and Darcy equation was developed

Micro structure
- Methyl cellulose increases dimensional accuracy and compressive strength, by retaining water

After printing treatment
- Water curing increases the compressive strength significantly by activating the remaining 'hydration potential'
- Combined with particle functionalization up to 41 MPa were achieved

Key collaborations in 1st funding period

A05 — Integration of fibre winded reinforcement into the SCA process.

C05 — Development and testing of dry joint topologies.

Large scale demonstrator

Particle-Bed Breuer – in collaboration with:
- C03: Concept for functionalisation
- C05: Concept for element jointing
- C06: Project consulting
- Additive Tectonics: Large scale printing
- AMtoArch: Design

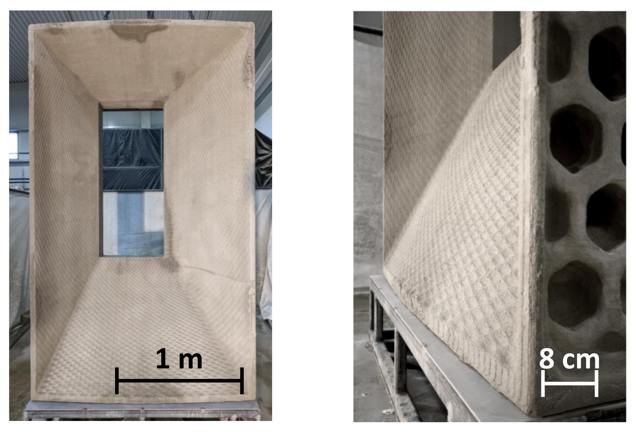


Fig. 1: Front view (left) and insulation details (right) of the Particle-Bed Breuer demonstrator.

Project status

Particle functionalization
- Particles were functionalized with coatings
- Influence on bulk solids and printed specimens properties was evaluated

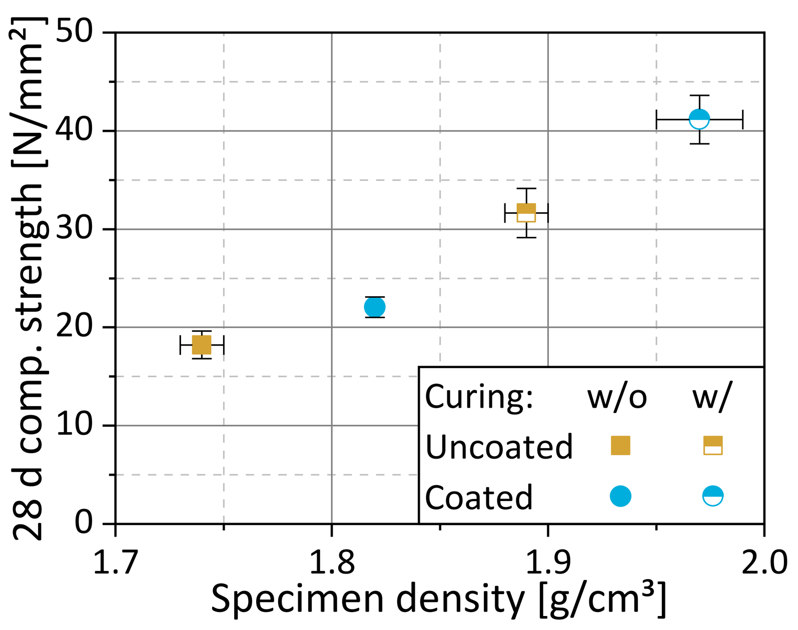


Fig. 2: Influence of particle functionalization and after printing treatment (water curing) on compressive strength.

Particle-bed compaction
- Specific control of compaction and investigation of its influence on packing density, compressive strength and micro structure

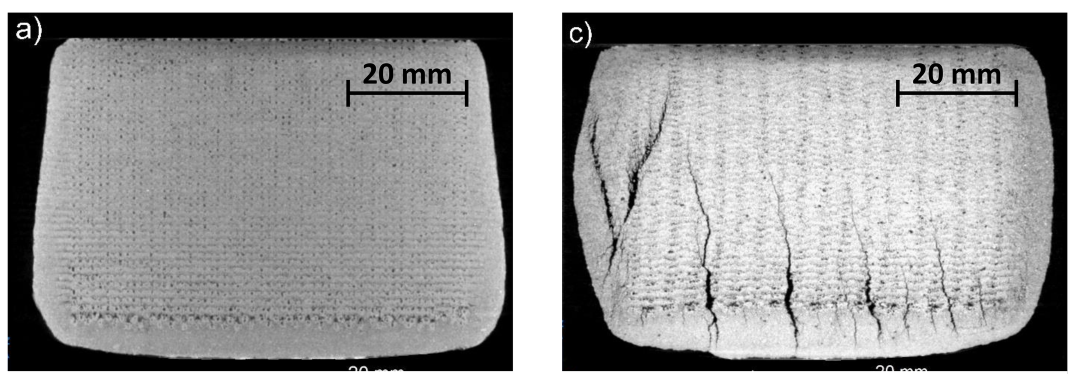


Fig. 3: µCT image of specimens printed at low (0.3) relative compaction (left) and high (0.9) relative compaction (right).

Liquid intrusion model
- Liquid intrusion model based on Young-Laplace and Darcy equation: $\tau = \frac{\varepsilon \eta H_{eq}}{S(t)H(t)\rho g K}$

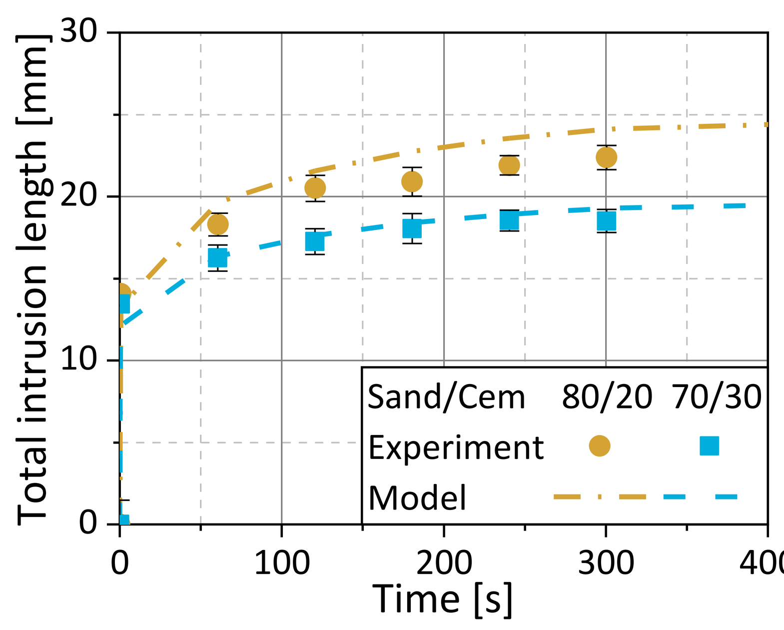


Fig. 4: Measured and modelled intrusion length into a particle bed for different sand to cement rations.

Liquid application
- Control of interlayer properties and strength by liquid application parameters

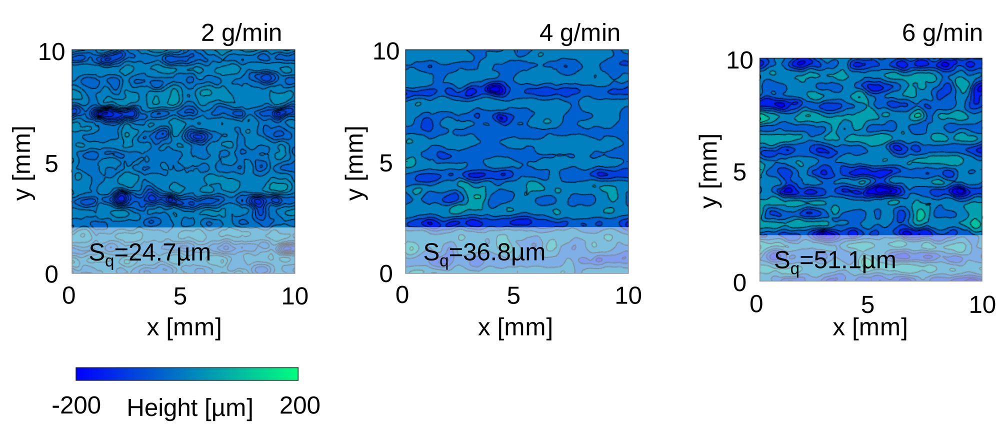


Fig. 5: Effect of liquid application pressure on surface topology of a printed layer.

Micro structure
- Investigation of the influence of methyl cellulose on: compressive strength, dimensional accuracy, specimen density

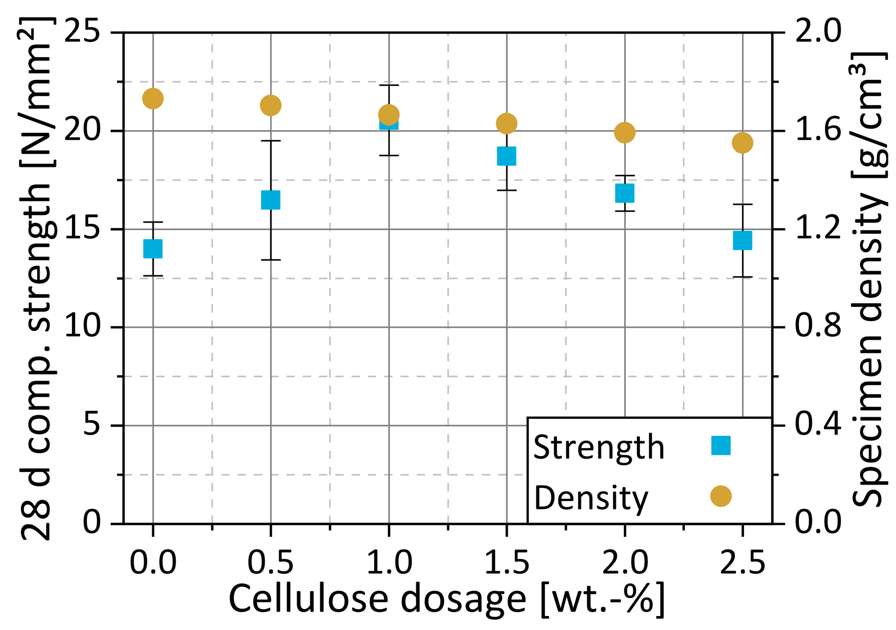


Fig. 6: Influence of cellulose dosage on compressive strength and density.

Reinforcement integration
- Development of two reinforcement strategies

Inter layer

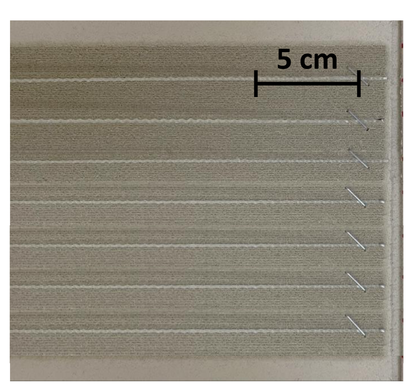


Fig. 7: Selectively activated particle-bed, with process parallel placed fibre rebars manufactured by A05.

Cross layer

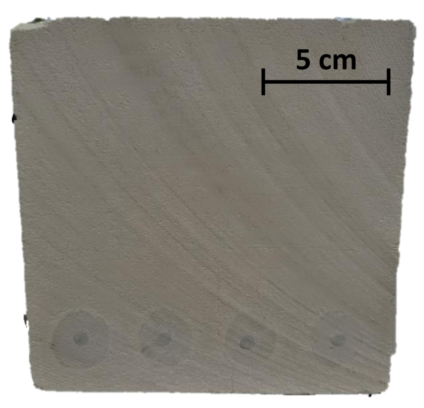


Fig. 8: Cross section of a bending beam with subsequent reinforcement integration.

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