Additive Manufacturing in Construction 2nd funding period: The Opportunity for Large Impact





Extrusion of Near-Nozzle Mixed Concrete – Towards Functionally Graded 3DCP

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Project aims of 2nd funding period

In the second funding period, the A03 project will focus on further developing **Functional Grading** (FG) through **NNM-3D concrete printing**. Therefore, we will:

Work programme

WP 1 Process engineering (Fottner)					WP 3
					Structural
				DOE	concrete

- **Optimize and extend** the NNM system for the use of enhanced materials and precise process control, including a novel Inline Quality Measurement (IQM) device.
- **Develop** a range of new sustainable, NNM-printable concretes.
- **Design** concepts for functionally graded elements.
- **Study** the relations between process, materials, and products through an extensive interdisciplinary experimental program up to large-scale structural testing.
- **Evaluate** the interactions between reinforcement elements, fibers, and concrete matrix to improve overall performance.
- **Collaborate** with other projects to produce large-scale demonstrators showcasing the advancements in concrete printing technology.



Fig. 1: Concept of functional grading applied to a beam



Fig. 2: Interdisciplinary interaction - Material process and product



Methods

Concept GRES V2

Collaboration Approach

• Interdisciplinary and cyclic research with focus on process, material, and structural performance.

Research Methods

- Advanced process monitoring using traditional parameter monitoring and a novel Inline Quality Measurement (IQM) device.
- Mechanical testing of fresh and hardened properties
- Large-scale **structural testing**.
- **Custom tests** for functionally graded elements with continuous strain fields.

Numerical Modeling

- **Correlate** process parameters to material properties structural performance.
- Develop as-built models of printed objects.

Development

- Utilize intermediate results for incremental materials and equipment development.
- Expand NNM prototype with continuous paste supply, modular mixing and dosing screws, multiple aggregate reservoirs, fibre dosing and IQM system.
- Three-phase hardware development for risk mitigation and incremental study.

New Materials (mortar to concrete)

- Upscaling for up to 8 mm aggregates
- Sustainability improvement: Low-CO₂ binders, recycled aggregates
- Fibre reinforced concretes printable with NNM



Fig. 3: Concept GRES V2 – Integration of two aggregate hoppers for automated gradation control: 1) Paste-compound hopper, 2) Water supply, 3) Fluid additives, 4) High-energy inline paste mixer 5) Hopper aggregate A, 6) Hopper aggregate B, 7) Mixing chamber, 8) Fiber-dosing unit, 9) Extruder and buffer, 10) Inline Quality Measurement device (IQM), 11) Nozzle

Key collaborations in 2nd funding period



Outlook 3rd funding period

The third funding period will aim at an **extended study** of the effects of Functional Grading and the **expansion of the application** of the FG through NNM-printing, by:

- In-depth analysis of the correlation between process parameters and concrete characteristics to improve comprehension of NNM production,
- Integration of NNM technology onto mobile robots,
- Combination of NNM-Extrusion with other technologies (shotcrete, fiber winding),
- Large-scale demonstration projects and fully automated operation (industry).

This will stimulate the **transfer of the NNM technology into practice**.

Funded by





Pastes based on alternative binders

Experimental methods and reinforcement integration



Modelling print objects in the fresh state



Quantify sustainability of NNMprintable concrete



