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Proposed topic for Master's Thesis

Development and optimisation of a nozzle system for the extrusion of ultra-high-strength concretes with carbon short fibres for use in the additive manufacturing process

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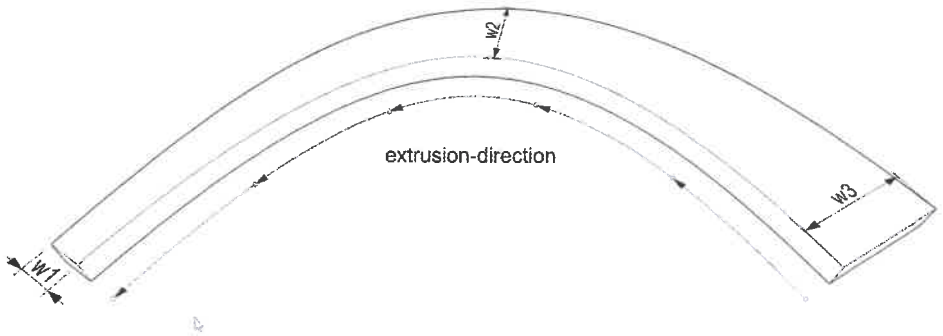
General:

Additive manufacturing represents one of the biggest changes in the construction industry in the last 50 years. On the one hand, the focus here is on increasing resource efficiency, and on the other hand on increasing architectural freedom. In contrast to completely filled concrete formwork castings, 3D concrete printing makes it possible to use material specifically where it is needed.

The aim of the master thesis is the development, optimisation and provision of a nozzle system that is capable of continuously changing the narrowing and widening of the concrete extrusion bar during the process.
Due to the application of an ultra-high performance concrete with carbon short fibres that are to be aligned in the extrusion direction by the conveying and extrusion process, another key feature of the nozzle is the ability to align the carbon fibres added to the concrete.



The development and design will be based on theoretical considerations through simulations and calculations and practical validation of prototypes in field tests on a 6-axis articulated arm robot.

The first step is a comprehensive literature research on extrusion systems in concrete construction (keyword: vibro-extrusion, flow alignment) and a requirements analysis, which serves as the basis for the nozzle development. In addition to the above-mentioned main aspects, the focus is also on low maintenance and cleaning requirements. This is used to develop a concept that is elaborated into a virtual prototype with the help of design calculations.

After production, the nozzle system is tested by means of field trials, which should reveal optimisation potential. In the course of conceptual design, development and construction of a continuously evolving prototype, these potentials are to be incorporated. In further field tests, the system will be mounted on a KUKA 6-axis articulated robot, tested according to the above aspects and optimised in subsequent steps. In addition to the design of the nozzle system, the connection to the feed system (concrete pump) and the control system must also be realised.

Procedure

- Literature study on existing extrusion systems in concrete construction
- Requirements analysis for nozzle system
- Development, calculation and production of a prototype by means of 3D printing
- Optimisation, further development of the prototype under variation of different, potentially decisive parameters
- Integration of the nozzle system into the production process
- Creation and implementation of an experimental programme
- Evaluation and interpretation of the various results and dependencies

Previous knowledge

- Motivation and interest in the topic

Literature

- Bauser, M., Sauer, G. and Siegert, K., 2006. Extrusion. Materials Park, OH: ASM International.
- Albar, A., Chougan, M., Al- Kheetan, M., Swash, M. and Ghaffar, S., 2020. Effective extrusion-based 3D printing system design for cementitious-based materials. Results in Engineering, 6, p.100135.
- A. Bentur and S. Mindess, Fibre reinforced cementitious composites. 1990.