Lehrstuhl für Werkstoffe und Werkstoffprüfung im Bauwesen
Master Thesis

Development of a Robust Rheological Quality Control for Extrusion Mortars in Additive Manufacturing

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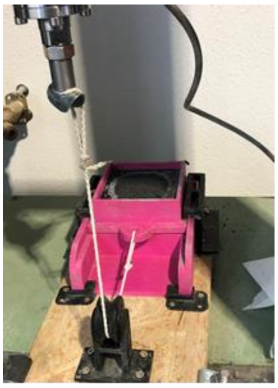
Problem Statement:

Concrete extrusion is a fabrication process in which objects are built layer by layer. In the construction industry, 3D printing using concrete extrusion is becoming increasingly attractive due to its ability to enable variable design possibilities without complicated formwork concepts, material savings through a conception of graded components, and accelerated construction processes. Despite the many advantages of the construction process, both process and material optimization are still subjects of ongoing research. The rheology of fresh concrete must be accurately controlled: During the pumping process, a low viscosity and yield stress of the concrete are needed to save pumping energy and foremost to prevent clogging in the pump. However, once the concrete strands are deposited, the material requires a high yield stress and sufficient stiffness to bear its own weight and a load of subsequent layers. This property is referred to as "buildability," and it directly determines the maximum possible vertical construction speed.

In the Near-Nozzle-Mixing method, flowable cement paste is pumped and homogenized with aggregate just before the deposition at the nozzle. Instead of adjusting structural properties through chemical additives, as required in conventional additive concrete extrusion processes to quickly increase both viscosity and yield stress for buildability, the stiffness required can now be achieved by adjusting the ratio of slurry to aggregates. Physical (thixotropic) and chemically induced structural build-up (through hydration) further support the development of the structure.

To accurately quantify the development of buildability of the extruded strands, the development of the yield stress, structural build-up, and a deformation modulus of the material over time need to be determined. Conventional measurement methods include the Slug test (calculation of the yield stress), Slow Penetration test (development of the yield stress over time), the shear box test (yield stress and cohesion of the material), and the uniaxial compression test (failure criterion and deformation modulus). Rheological measurement methods that accurately determine viscosity, yield stress, and structural build-up are not applicable to stiff mortars and at best allow only qualitative assessments of material properties.


Scherkastenversuch


Compression test


Slow penetration test


Rheometrie

The goal of this master's thesis is to develop, based on previous investigations, a rheometric measurement method that provides reliable rheological parameters. The results are to be compared with known measurement methods and thus provide a scientific assessment of material development compared to applied measurement methods.

First, measurements are to be made on an inert, i.e., non-reactive model mortar. Particular emphasis in rheometry will be placed on the accurate development of optimal boundary conditions. This involves surface adhesion, material interaction with the rheometer, adjustment of measurement parameters, and meaningful analysis of the results. The aim is to be able to reliably determine the rheological parameters yield stress, the structural build-up, and the deformation modulus over time, providing the necessary parameters for simulation or predictive models of buildability.

Start: As soon as possible

Exposé before thesis start required

The Master's thesis includes laboratory work. A significant portion of the laboratory work will take place at our laboratory in Achering. Having a car would be advantageous for commuting to the location.

Date and signature