Experimental characterization and numerical modelling of 3D printed concrete
Controlling structural behaviour in the fresh and hardened state

3D Concrete printing provides the potential to enhance the productivity and to reduce the environmental impact of the construction industry. New design solutions with increased functionality are illustrated by a rapidly growing number of showcase projects appearing in practice.

The adoption of this new technique comes with an added complexity compared to traditional manufacturing. Due to the absence of formwork, the freshly extruded concrete should be sufficiently strong and stable throughout the printing process. Moreover, because of the layerwise nature of 3D printing, the final product is composed of multiple layers which should adhere sufficiently.

This research was performed to remove the added complexity, by controlling the structural behaviour in the fresh and hardened material state. A 3D concrete printing facility was realized to study the printing process on both small and large scale. Numerous experimental procedures were developed to characterize the essential mechanical properties of printed concrete. These were used as input for a custom developed numerical model, to analyse the structural behaviour during 3D printing.

The numerical and experimental methods were applied in large scale 3D printing projects. They were used to facilitate the design process, provide input for structural analyses, and successfully optimize the printing strategy.

Figure 1: Experimental testing of a 3D printed concrete sample, to assess the bond strength between layers.

Figure 2: A numerical simulation of the 3D concrete printing process of a cylindrical object. The simulations show if and how an object may fail during 3D printing.

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Company: Eindhoven University of Technology
Promotor/Supervisor: Prof.Dr.ir. Theo Salet and Prof.Dr.Ing. Patrick Teuffel
Current Employment: Assistant professor at Eindhoven University of Technology

Department: BUILT ENVIRONMENT

Dr.Ir. R.J.M. Wolfs