

Reflection

Graduation Process

The chosen graduation topic of additively manufactured thin-shell concrete formwork was my own proposal and is thus not part of any research conducted at TU Delft as such. However, the research is part of a larger theme at the ETH Zurich, more specifically at Gramazio Kohler Research in collaboration with the Physical Chemistry of Building Materials group. In a research stream dubbed 'Digital Concrete', several novel methods of fabricating concrete structures are explored. Within this research stream, the project is well grounded. The concept of 3D printing formwork and simultaneously filling it with accelerated concrete stems from another research project developed at the ETH Zurich: Smart Dynamic Casting.

The chosen research approach of empirical research, constantly testing and validating hypothesis through physical experiments has been successful. Through the generation of several prototypes the research has been advanced and in every successive prototype new design and fabrication aspects have been explored. Although successful in advancing the research, the adopted research approach at times also felt like 'trial-and-error'. With new technologies such as additive manufacturing, this is often the way to gain knowledge without having to solve every problem. It can, however, be labour intensive.

The relationship between research and design is an interesting one and plays a substantial role in this project. My approach in combining research and design is that research always has to inform the design. In this particular project this can be illustrated by the following example: To make a large object feasible for 3D printing it was found necessary to embed a certain pattern into the structure. Research was conducted to study the effects of the pattern on the feasibility of printing. After this, the results could be fed back into the design, adapting the design based on the outcome. In the end, the research finds went on to inspire the design language used.

No moral or ethical dilemmas were encountered during the process.

Societal impact

The achieved results are expected to be directly applied into practice, as the main research question directly addresses the practical application of the method. The project also potentially has a high contribution to sustainable development. As concrete formwork is a very wide-spread source of construction waste material, any reduction of this waste material can have a vast contribution.

A second contribution could be in the form of reduction of concrete usage. Many concrete structures are over dimensioned, simply because formworks do not allow for complex geometry. Using additively manufactured thin-shell formwork it is possible to design more efficient structures, thus reducing the quantity of concrete used in the construction industry. This can have a large effect on architecture and the built environment as a whole, enabling architects and designers to design and build structures with non-standard geometries.

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