Ultra High Performance Concrete in Fabric Formworks

Introduction
Ultra High Performance Concrete (UHPC) is one of the ongoing innovative developments in structural engineering. Its unique and improved properties compared to common concrete types provide designer and engineer with new possibilities. These characteristics however, call for a different approach when designing and producing elements. It is therefore interesting to combine this innovative material with unusual production methods, like applying fabrics as formwork. Combining the pros of the UHPC with the benefits of fabrics might lead to more economic, durable or esthetic solutions.

Topology Research
When combining the findings of a literature review, it is clear that that combining UHPC with fabric formworks can call for optimized, uncommon shapes. These shapes can be realized by so called topology software. To get an idea of possible optimization processes, different types of software can be used, varying from simple modeling to complex Finite Element programming. In this research both Topostruct and SolidThinking Inspire are used (fig. 1).

Analytical Research
An analytical research is carried out by using Oasys GSA and Abaqus. Different load situations are considered and the structure is analysed by both a 1st and 2nd order analysis. Additionally, the influence of gravity loading and minimum eccentricity is discussed.

Firstly, form finding is carried out in Oasys GSA, analyzing multiple symmetrical and asymmetrical load cases. This results in an optimized structure that is mainly axially loaded. Then UHPC properties are implemented and, using basic mechanics, the cross section of each branch can be optimized. This is done twice, both considering and neglecting a minimum eccentricity (fig. 2). These structures are modelled and checked in Abaqus. The analytical research is concluded with a 2nd Order study, using the multi-layer and difference model of Thomas Paus in Wolfram Mathematica.

Experimental Research
The aim of this experimental research was to find theoretical background on the principles of fabric formworks together with basic aspects about the combination of fabric formworks and concrete. These two goals need to be investigated to achieve the main goal: being able to design a fabric formwork and verify the principle by experiments.

In order to design a formwork, material properties and connection properties of basic low-cost, water tight material and connection types are determined via tensile tests. Finally, a scale model has been constructed, meeting all the requirements from both analytical and experimental research.