Introduction in Research; Ultra High Performance Fibre Reinforced Concrete (UHPFRC)

It is no secret that concrete composites nowadays can achieve greater mechanical performances than ever before. But it is only since the last decade that structural applications start to show themselves more frequently. These applications are about Ultra High Performance Concretes, also known as UHPC. These types of mixtures now take over the market of ordinary concretes because they improve them on every level. Even the necessity of steel reinforcement is now under debate with fiber reinforcement. The developments open a new door in the way we can design our buildings; much lighter and efficient that is. In the same way we make use of the specific material properties of steel, for example in H-beams, we should also now optimize UHPC.

The relationship between research and design

My research was focused on the architectural and structural application of Fiber Reinforced UHPC (UHPFRC). A literature research was conducted on the properties and production process of UHPFRC and compared with conventional materials like steel and ordinary concrete. The current applications of UHPFRC were also explored (frame of reference). With this information some principle, basic designs were introduced and tested with the help of computer analysis.

The outcome of my P2 research always served as direct input in design decisions, since my method is defined as “Research by Design”. The results of these studies are written in a sort of ‘design code’. This code consists of a list of rules or guidelines for architectural design with UHPFRC’s.

These design guidelines were used in the design of a new multifunctional public sports complex near the Westerpark in Amsterdam. The building is part of a recreational route from east to west trough the Brettenzone. The Brettenzone was provided as an interesting area by the Architectural Engineering studio where some interesting assignments may derive from. This is a strip of land which is a so called ‘Green Finger’ and stretches all the way from the outskirts of Amsterdam to the city center.(fig. 1) We were to select a specific site and a function by our choosing. The site chosen for my design is a stretch of allotments near the Westerpark. In this area there are some developments coming up according to the ‘Structuurvisie Amsterdam 2040’. The northern part will be developed into a residential area with about 40.000 new households. (fig. 2) This will go hand in hand with the development of appropriate facilities, like shopping malls, restaurants, parks, sport facilities etc. In this part of the Brettenzone lies the opportunity to develop some of these facilities. I choose to design a multifunctional sports complex for two reasons. The first reason to design a sports complex was because of the existing demands for new sports facilities in this specific area. The second is from my technical fascination to design a main structure with UHFPRC, to do this I need a challenging test case. A sports hall seemed like a good challenge since this is a function that would require a certain structural span and with that the structure could really define the architecture of the whole building.

In general the building consists of 3 volumes, each representing its own function; a multifunctional sports hall, a competition pool and a center for various social activities (fig 3). The concrete structure, which is a so called ‘exoskeleton’, will follow the shape of these 3 volumes in such a way, that the structural elements will be as repetitive as possible. This means that to be able to construct these shapes, all the columns in the facade must be rotated slightly according to the curvature (fig 4). The arches that lay on top of them are made as perfect circle arcs with the same radius all over, which
makes the spanning structure completely repetitive. The portals that are created then will not be stable in all directions by themselves. The connecting center volume will take care of the stability for both sports functions. This center volume will have an inside and outside concrete structure. The outside structure will align straight with the columns of the ‘wings’, yet the internal structure will be diagonal providing stability for both wings and at the same time enclose an atrium for various social activities. This is the core were several recreational routes come together and cross each other on different levels.

**The relationship between the theme of the studio and the subject/case study chosen by the student within this framework (location/object)**

The Architectural Engineering studio focusses on the integration of present day and future technology with architecture. To create a seamless transition between these two research fields. So the approach encouraged by the studio is to develop a fascination for a technical research topic and with this information come up with new architectural innovations. In the end, as with any architectural studio, it will result in a complete plan for a building.

My technical fascination was on the architectural possibilities of UHPFRC’s. It is a relatively unknown building material in the architectural field with very promising technical specs. When compared to ordinary concretes, these materials show increased mechanical performance in compression, tension en flexural strength. Also the density of the material makes it very resistant to water and acid attacks that would cause decay in normal concretes. So it is also a durable construction material for outside applications.

Unfortunately, most of the current applications are in bridges or façade panels only. I think here lies the opportunity for me to find out what this material could mean for the main support structure of a building. Not only to support it with the least material possible, but also allow to show this to the outside, and create the possibility for people to experience this slenderness and elegance. By applying the knowledge of the material in early design stages I was truly able to integrate the technology into my architecture.

**The relationship between the project and the wider social context**

This project is a test case of an architectural application of UHPFRC. It shows us how UHPFRC can be handled efficiently in the design of a main structure of a building. This particular way of applying has not been done before, and therefore one can be inspired and learn a great deal from it.
Figure 1; The Brettenzone, recreational Green Finger.

Figure 2; Westerpark and its surroundings. The assignment was to design a sports complex that will serve as connection between the residential areas around the park. The red line indicates a route that will connect the Brettenzone from east to west, the orange dotted lines represent the necessary connections between the residential areas and recreation from north to south.
Figure 3; Volumes of the complex.

Repetitive structural UHPFRC elements

Figure 4; Structural elements creating the volumes and supporting the elevated walkways from the east-west route through the Brettenzone.