Zukunft Bau

KURZBERICHT

Titel

Development of sustainable, module-based, concrete structures made of Ultra-High Performance Concrete (UHPC).

Anlass/ Ausgangslage

Based on the present scientific findings and developments in the field of Ultra-High Performance Concrete (UHPC) a sustainable, module-based und lightweight concrete structure with load bearing elements made of UHPC is to be developed. Clothoid shaped shear connectors are tested for their suitability to connect the different parts of the construction among each other, as the components have to be precast to meet the requirements for UHPC.

Gegenstand des Forschungsvorhabens

In order to develop a sustainable and lightweight modular construction system made out of UHPC elements (see Fig. 1) initially the present scientific findings regarding the used components (UHPC and clothoid shaped shear connectors) and the different joining technologies were analyzed (see Fig. 2). Compared to normal strength concrete UHPC has a lot of advantages as for example better durability, higher strength and therewith the possibility to build more slender structures. These advantages can be put in to praxis by using UHPC as the key component of a modular construction system.
Furthermore the research report shows the potential field of application for a modular construction system made of UHPC elements as well as the advantages of this system.
Based on these findings a testing program was developed and carried out. Within the testing program the load bearing elements of the modular construction system (columns and beams) were examined by testing different types of cross-sections. Therefore in each case a test series with twelve experiments case was carried out for UHPC composite beams (beam or tee beam cross-section) and UHPC composite columns (octagonal shaped cross-section).
The composite beams were concreted with a web width between 4.0 and 6.0 cm and a steel flange on the bottom side (see Fig. 3 and 4). By this way the steel flange can be used as joining element and as external reinforcement. The connection between the concrete and the steel elements was established by welded-on, continuous, clothoid shaped shear connectors. The experiments showed, among other things, the influence of the value of partial shear, the steel fiber content, the inner lever arm, the slenderness and the shear strength to the loadbearing and deformation behaviour of the composite beams. Also the loadbearing effect of the steel flange was confirmed by the experiments. In summary the assumed very high loadbearing capacity of the composite beams was confirmed. The recalculation of the carried out experiments with FE programs showed a very good accordance. Due to this good accordance a transfer of the testing results to other cross-section shapes becomes possible.
The UHPC composite columns were experimentally tested by using 2.5 to 3.0 m high, eccentric loaded columns with an octagonal cross

section (see Fig. 5 and 6). Similar to the composite beams the steel flanges of the shear connectors where located on the outside and supposed to be used as joining element as well as external reinforcement. The expected influence of the load eccentricity and direction and the slenderness on the loadbearing and deformation behaviour of composite columns made out of UHPC has been demonstrated. Also the complete activation of the external steel flanges as reinforcement was documented. Due to the very good bond between the clothoid shaped shear connector and the UHPC furthermore a complete jointed cross-section can be assumed and therefore the recalculation of the experiments according to Eurocode 4 showed a very good coincidence with the testing results. Also the simulation of the carried out experiments within FE programs resulted in very similar values regarding the maximum load bearing capacity and the horizontal deflection. As a result of this calculation and by means of the measured steel stresses and relative displacement the loadbearing and deformation behaviour of UHPC composite columns was comprehensible documented.

As a next step the possibilities for joining the developed elements among each other and to existing composite floor systems respectively were investigated. As a result the fundamental suitability of the existing composite floor system for the use within the module-based construction system with UHPC elements was shown. By using the external steel flanges a connection between the individual elements can be achieved quite easily by applying usual and already known steel construction joining technologies.

The final step included the embedding of the individual modular elements in an overall system for a module-based construction system. Within this task sample construction concepts were developed and the application of the tested components was shown for an exemplary building.

Fazit

Objective of the present research project was to develop a module-based construction system with load bearing elements made of UHPC. The experimental and numerical investigation proved the suitability of the UHPC composite beams and columns for the use in the modular system as slender but ductile construction elements with a high loadbearing capacity. Along with the already existing composite walls and floors all construction elements for modular system are available. However, before it is possible to put this system into practice verification of the results as well as test applications and a discussion about outstanding issues (e.g. limitation of the crack width) are necessary.

Eckdaten

Kurztitel: Modulare UHPC Konstruktionen

Forscher / Projektleitung: Lehrstuhl für Massivbau (TUM), Lehrstuhl für Metallbau (TUM), SSF Ingenieure AG / Projektleitung: Lehrstuhl für Massivbau, Prof. Oliver Fischer

Gesamtkosten: 239.356,00 €

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BILDER/ ABBILDUNGEN:

5 - 7 Druckbare Bilddaten als **eigene Datei** (*.tif, *.bmp, ...) mit der Auflösung von mind. 300 dpi in der Abbildungsgröße (z.B. Breite 10 - 20cm). Bilder frei von Rechten Dritter.

Bildnachweis jeweils:

Bild 1: Components_modular_system.jpg
Bildunterschrift: Components of the modular systems (walls and beams plotted in middle section)

Bild 2: Verformung_Dübel_real-FE.jpg
Bildunterschrift: Deformation comparison for composite dowels – FE-simulation and real specimen

Bild 3: Versuchsaufbau_schematisch_Träger.jpg
Bildunterschrift: Schematic representation of the experimental setup for the composite beams

Bild 4: Versuchsaufbau_real_Träger.jpg
Bildunterschrift: Composite beam made of UHPC installed in the test setup

Bild 5: Versuchsaufbau_schematisch_Stütze.jpg
Bildunterschrift: Schematic representation of the experimental setup for the composite columns

Bild 6: Versuchsaufbau_real_ Stütze.jpg
Bildunterschrift: Composite column made of UHPC installed in the test setup