Zukunft Bau

STRUKTUR / GLIEDERUNG KURZBERICHT

Titel

Development of thin UHPC wall-elements with appropriate joining techniques.

Anlass/ Ausgangslage

Ultra-High Performance Concrete (UHPC) allows the production of extremely thin but high-strength elements. The application of UHPC for concrete walls will reduce the thickness and thus the weight of the walls significantly. Manufacturing of these thin wall-elements will predominantly take place in factories. Consequently, joining techniques for precast UHPC-elements have to be developed. In addition, the stability of the wall-elements has to be evaluated.

Gegenstand des Forschungsvorhabens

Ultra-High Performance Concrete (UHPC) is a high-tech material allowing the production of extreme thin but high-strength elements. The application of UHPC for common concrete elements, e.g. wall-panels and beams, will reduce the thickness and thus the element weight significantly. Furthermore, such elements are extreme durable and life-cycle-costs will be reduced significantly. Therefore, a method has to be developed in order to connect the thin UHPC-panels (see Fig. 1) to other structural elements on site.

At first basic research was focused on the different connection techniques for UHPC e.g. gluing or mechanical connections. It was found that a mechanical connection with continuous shear connectors, which are also known as composite dowels was best fitted for this type of structure. If continuous shear connectors are embedded in wall-panels during the production process at the factory, the connection between the wall element and other structural elements can be arranged by means of welding or with bolts.

Experimental investigations with composite dowels demonstrated an excellent load-deformation behavior, when tested with UHPC-beams or plates. The structural behavior of continuous shear connectors in thin wall-panels differs significantly from the behavior in plates since the concrete failure mechanisms are different (see Fig. 2). To analyze the shear-carrying behavior in thin wall-panels of UHPC a series of Push-Out-Tests has been carried out.

Composite dowels with a clothoidal shape and a maximum thickness of 10 mm have been used for the Push-Out-Tests. The UHPC-elements had a thickness between 40 and 60 mm and the Push-Out-Specimen and testing machine are displayed in Fig. 3 and Fig. 4.

The results of the Push-Out-Tests show that composite dowels in UHPC can carry shear forces up to 1250 kN/m before a brittle failure occurs. The concentrated load introduction leads in thin UHPC-elements to splitting tensile forces and results in a concrete-splitting. If steel failure is predominant shear forces up to 800 kN/m can be

transferred and the failure mechanism is very ductile. A brittle concrete failure should be prevented by choosing continuous shear connectors which start yielding before the concrete fails. Continuous shear connectors can be designed according to the already existing design formulas for normal strength concrete.
In addition to the connection technique also the stability behavior of thin UHPC-walls has to be investigated in order to construct safe and economically advantageous buildings with these thin walls. Already existing research results from buckling tests of filigree UHPC-elements were compared to the theoretical buckling loads according to DIN EN 1993-1-5:2010 for steel structures and a design formula on the basis of this code was developed. Furthermore the buckling tests of the thin UHPC-elements were compared to results from finite element calculations.
The behavior under lateral loading was examined with a UHPC-cantilever. For this reason a thin UHPC-panel with a clothoid-shaped composite dowel at the bottom was fixed to the ground by welding the clothoid-strip to a rolled-steel section and a lateral load was applied at the top of the specimen (see Fig. 5). These experiments were also recalculated with a finite element program. Numerical analyses were afterwards used to evaluate the buckling-behavior of wall-panels with openings.
In addition to requirements concerning the connection and the stability of UHPC-walls, analysis regarding the building physics and building services engineering were conducted. Some details were proposed involving the running of cables and pipes as well as the thermal insulation and fire protection system.

Fazit

Composite dowels can be used in filigree UHPC-walls to connect two structural elements. The clothoid-shaped composite dowel can be designed similar to the application in normal strength concrete if a UHPC-splitting is prevented.
The buckling strength of such wall-elements can be estimated by design formulas which were derived from DIN EN 1993-1-5:2010. A positive influence of the fixed support at the panel-edges should not be considered for the design.
Filigree wall-panels of UHPC are even more sustainable if they are used in modular buildings, where parts like columns, walls, beams and floors can be assembled, disassembled, recycled or re-assembled. Hence, a complete modular construction system should be developed to fully exploit all the advantages of UHPC-panels.

Eckdaten

Kurztitel: Wall-panels made of UHPC

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

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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:

Fig. 1: Wandelement.tif
Bildunterschrift: UHPC-panel with composite dowels

Fig. 2: Verbunduebelleisten.tif
Bildunterschrift: Application of composite dowels in beams or plates (left) and in panels (right)

Fig. 3: Push-Out-Koerper_englisch.tif
Bildunterschrift: Prefabricated steel element (left) and PO-specimen with midplane-cut through UHPC (right)

Fig. 4: Versuchsaufbau.JPG
Bildunterschrift: Experimental test set-up of Push-Out-Specimen with optical measurement equipment

Fig. 5: Einspanngrad-Versuch.tif
Bildunterschrift: UHPC-cantilever with composite dowel and mid-plane cut through UHPC