Zukunft Bau

STRUKTUR / GLIEDERUNG KURZBERICHT

Titel

Langfassung Titel:
„Ultra-High-Performing Timber Walls - Use of slender ultra-high performance concrete lamellas in cross laminated timber elements to increase the load bearing capacity. “

Anlass/ Ausgangslage

kurze Beschreibung des Problems und des Lösungsansatzes
max. 450 Zeichen (mit Leerzeichen)

In multi-story buildings, high vertical loads arise in load-bearing wall, especially in lower floors. By combining ultra-high-performance concrete with timber, a sustainable and high-performance composite material is to be created, which, in addition to the general advantages of timber, is particularly characterized by its high load-bearing capacity that can be adapted to local loads.

Gegenstand des Forschungsvorhabens

Beschreibung der Arbeitsschritte und des Lösungswegs
max. 4.300 Zeichen (mit Leerzeichen)

The combination of ultra-high-performance concrete (UHPC) and timber in wall elements is intended to enable walls to be slim, highly load-bearing, and adaptable to local loads. The walls have a core of ultra-high-performance concrete which mainly absorbs the normal forces. The external timber cross section absorbs tensile and compressive forces resulting from wind and/or imperfections and prevents the slender concrete core from buckling. Figure 1 shows an exemplary structure.

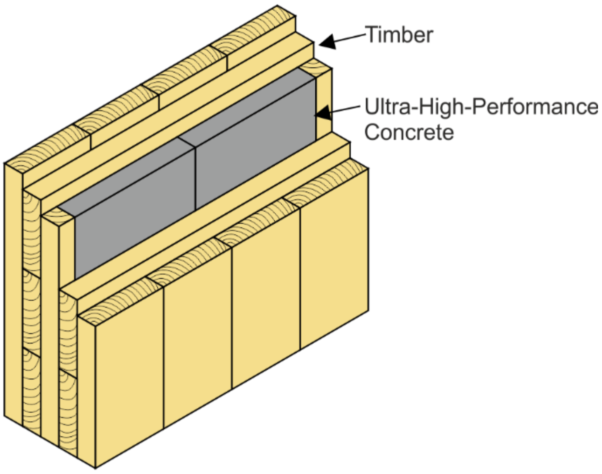

Figure 1: Wall element with glued in ultra-high performance concrete lamellas

In contrast to known methods of joining timber and concrete, e.g. mechanical connectors or grouted joints, the two materials are adhesively bonded together. The industrial bonding takes place within the framework of cross laminated timber production. For this, in the production process of cross laminated timber, single or multiple timber boards are replaced with "boards of concrete". Three decisive steps are necessary to produce wall elements with a composite cross-section. At the beginning, a precast concrete plant produces the boards or lamellas of ultra-high-performance concrete and sends them to a cross laminated timber manufacturer. This manufacturer inserts the concrete lamellas into the wall elements at previously defined spaces in the regular production process. After pressing the wall elements with composite cross-section, they are cut to size using computer aided manufacturing.To make this production process possible, timber and concrete need to be bonded with adhesives which are common in cross laminated timber production.

At the beginning of the research project, the feasibility to glue timber to UHPC was investigated with different adhesives, concrete types, and concrete surface treatments using small-format compression shear tests. Figure 2 shows the corresponding test setup. Independently of the concrete used, a sanded concrete surface bonded with a one-component polyurethane adhesive showed promising results.

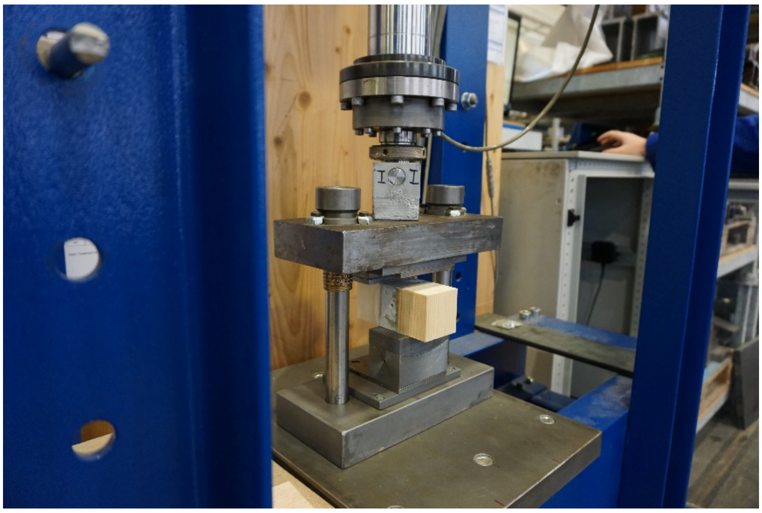

Figure 2: Test setup of small format compression shear test

Based on the small format compression shear tests, tactile tests on durability were carried out with promising combinations of concrete, concrete surface treatment and adhesive. For this purpose, established procedures from the testing of adhesives were adapted for the production of load-bearing timber components. Here too, promising results were achieved with a sanded concrete surface bonded with a one-component polyurethane adhesive. With this combination of concrete and adhesive, inclined compression shear tests were carried out with bonding lengths of up to 45 cm. In these tests, the failure was largely applied in timber and small relative displacements between timber and concrete occurred, which is why a rigid connection of the two joining partners is assumed.

Finally, tests on wall segments were carried out on a scale of 1:1. The 50 cm long and 2.84 m high, five-layered walls with 15 cm or 16.5 cm wall thickness, timber layer thickness 30 mm, and concrete core thickness of either 30 mm or 45 mm, either had a continuous concrete core or had a wall core made of timber and concrete alternately. The different cross-sections are shown in Figure 3. The centric and eccentric tests were carried out in a standard testing machine with displacement control. Fig. 4 shows the schematic test setup of a centric test on the left and the actual test setup of an eccentric test on the right

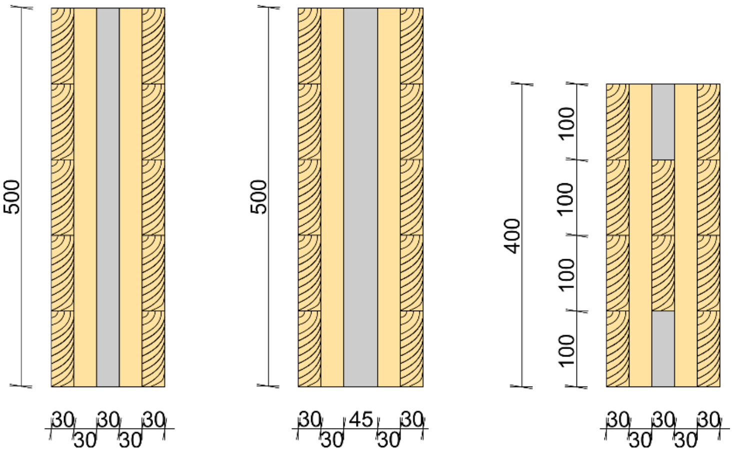

Figure 3: Tested cross sections

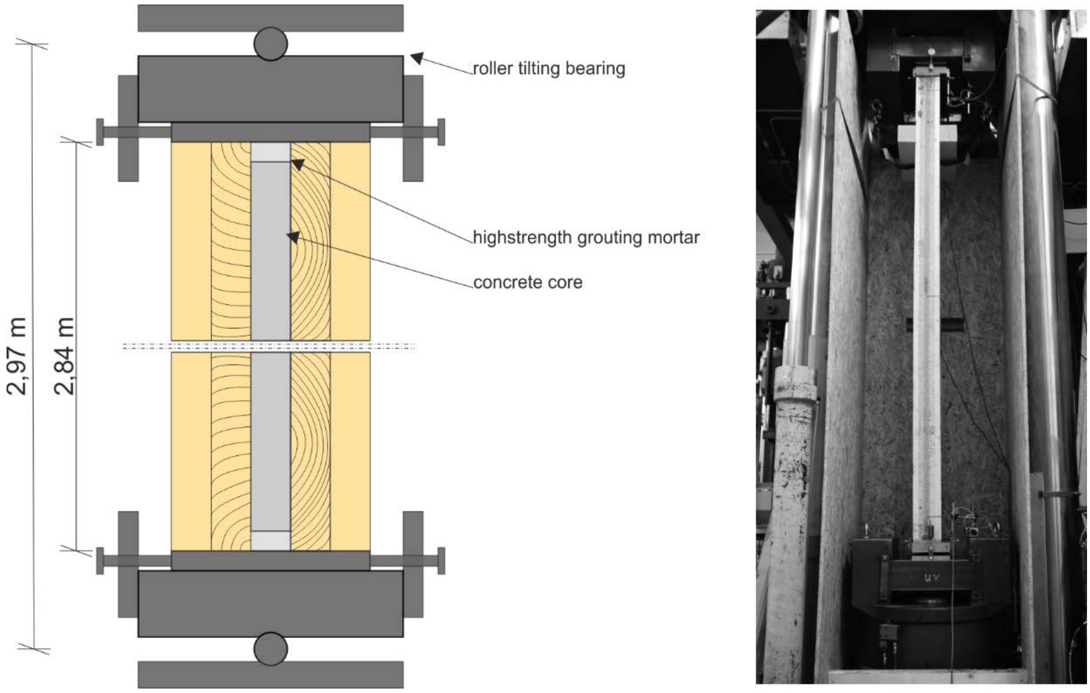

Figure 4: Schematic test setup of a centric (left) and real test setup of an eccentric (right) test of a wall segment

The centrically loaded walls failed abruptly and showed no apparent material damage. Most of the eccentrically loaded walls possessed a ductile load bearing behavior, here the pressure folds in the outermost timber lamellas on the compressed side of the wall were clearly visible. Only in three eccentrically loaded walls did the adhesive joint fail and an abrupt component failure occurred Modelling the tests with the shear analogy method, considering the altered stiffness values for concrete, showed good agreement with the test results. Figure 5 shows the horizontal deformation in the middle of the wall determined in the experiment and calculated for different timber strength grades for an experiment with 10 mm load eccentricity.

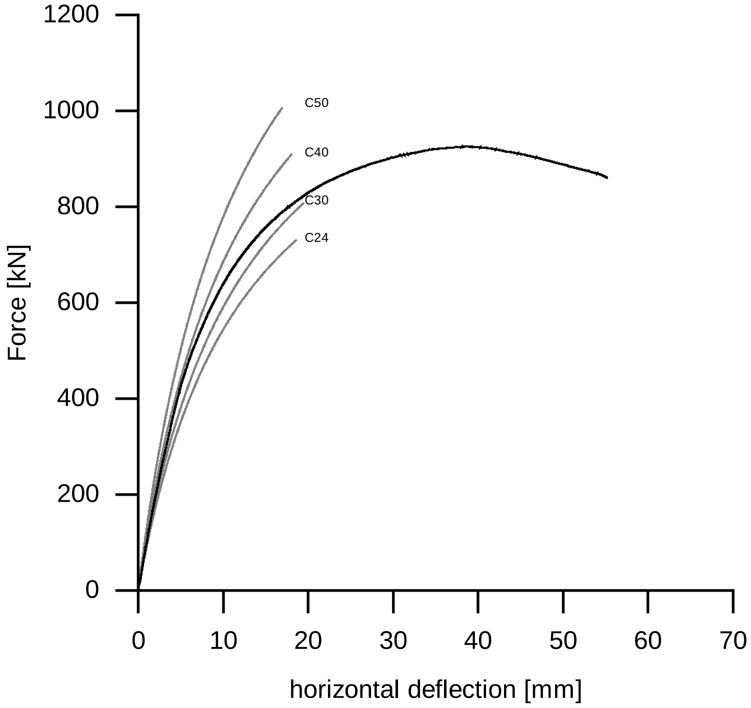

Figure 5: Comparison of calculated with measured horizontal deflection in the middle of the wall for an experiment with 10 mm eccentricity.

Fazit

Beschreibung der geplanten Ziele und der erreichten Ergebnisse
max. 700 Zeichen (mit Leerzeichen)

On the basis of the research project carried out, it could be shown that it is possible to produce a load-bearing bond of ultra-high-performance or high-performance concrete and timber with approved adhesives, which are common in cross laminated timber production, with regard to the short-term load bearing behavior. Due to the good agreement of the recalculation of component tests based on the shear analogy with the corresponding tests, it is proposed to calculate the walls investigated in this research project with the shear analogy method. It is not possible to give a blanket statement on the increase in load-bearing capacity, since this depends on the respective wall structure, the slenderness, and the load eccentricity to be applied.

Eckdaten

Kurztitel: Ultra-High-Performing Timber Walls

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Gesamtkosten: 238.587,20 € €

Anteil Bundeszuschuss: 163.016,00 €

Projektlaufzeit: 24 Monate

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: Beispielhafter_Wandaufbau.jpg
Bildunterschrift: Wall element with glued in ultra-high performance concrete lamellas

Bild 2: 03_Versuchsaufbau_Scherversuche.png
Bildunterschrift: Test setup of small format compression shear test

Bild 3 06_Wandaufbau.png
Bildunterschrift: Tested cross sections

Bild 4: 06_Bauteilversuche.png
Bildunterschrift: Schematic test setup of a centric (left) and real test setup of an eccentric (right) test of a wall segment

Bild 5: V_D_30_10_Berechnung_Versuch.gif
Bildunterschrift Comparison of calculated with measured horizontal deflection in the middle of the wall for an experiment with 10 mm eccentricity.