Zukunft Bau

Summary

Title

Investigations on HPC shear dowels as shear connectors in timber composite beams

Motive

In this research project, the load bearing capacity and the deformation behavior of new shear connectors made of high performance concrete (HPC) for timber composite beams should be investigated. The new connection system consists of HPC embedded dowels in timber beams, which are tilted by 10° around their axis to avoid a vertical slip between concrete slab and timber beam.

Aim of the research project

In order to get information to determine the basic constellation of the push-out tests, three preliminary tests were carried out. In these tests, it should be noted that the shear strength of timber has limited the load bearing capacity of the shear dowels. For the further push-out tests the shear dowels were designed, that a shear failure occurred in concrete.

A total of three series of push-out tests with 10 different configurations were carried out. For each configuration, three specimens were tested. In order to determine a suitable connector, the shape, geometry, distance, arrangement and reinforcement type of the HPC dowels had to be varied. The shape of recesses in the timber beam were conical or slightly tilted cylindrical to avoid a vertical slip between concrete slab and timber beam. The main difference between series V1 and series V2 is that the arrangement of the HPC dowels in series V2 was staggered to enable a larger distance between the dowels. In series V3, four reinforcement types were tested regarding their influence on the load bearing and ductility behavior of the HPC dowels. The tests with HPC dowels, which were tilted by 10° in cross direction, showed higher failure loads than those, which had a conical form. Nevertheless, the deformation behavior of all tests of series V1 and V2 was similar but did not show improved ductility. The increased diameter and depth of dowels caused equivalently a higher load bearing capacity. The reinforcement type influences not only the load bearing capacity but also the ductility behaviour of the HPC dowels. The dowels with perforated pipe and double-headed anchor as reinforcement showed a better ductility behavior. The reinforcement type double-headed anchor proved to be simple and practical.

The new connection system should be a part of a floor system, which is made of semi pre-cast PI-slabs with a subsequent in-situ concrete layer. Therefore, three-point bending tests on five large-scale timber-concrete composite beams (5 m long) were constructed and carried out.

The bending tests included one preliminary test and four other tests, in which one parameter such as concrete slab thickness, number or distance of the HPC dowels was varied to obtain information about their impact on the load capacity and the deformation behavior of the composite beams. HPC dowels reinforced with double-headed anchors were used as shear connectors. In all tests, the load bearing capacity of the composite beams was limited by the bending tensile strength of the timber beams. Therefore, HPC dowels could be considered as high performance connection system.

Furthermore, the results showed the affection of the varied parameters to the deformation behavior (bending and slip between concrete and timber) and the reinforcement stress in the HPC dowels.

In subsequent steps, numerical investigations on the new connection system were carried out to obtain detailed information about the load bearing behaviour and to optimize the HPC dowels. The FE simulations were carried out on the preliminary three-point bending test and push-out tests. The obtained qualitative strain distribution and deformations from FE analyses were plausible and replicable. The deformations in FE results were similar to the measured deformations in the experimental tests.

Conclusion

The tested new shear connectors for timber concrete composite beams could be reinforced in various ways, which create an efficient connection system. This connection system is applicable to build a timber concrete composite beam made of a semi pre-cast PI-slab with a subsequent in-situ concrete layer. In this project, the load bearing and deformation behavior of the HPC dowels were firstly tested by push-out tests. After that, three-point bending test on five large-scale timber-concrete composite beams and numerical analyses were carried out. In conclusion an approach for a practical design model was developed, which could be applied for the structural design of these composite beams.

Basic data

Short title:
Timber composite with high performance concrete

Researcher:
Dr.-Ing. Christian Kohlmeyer; Prof. Dr.-Ing. Jürgen Schnell

Costs:
127.877,13€

Portion federal subsidy:
73.640,77€

Project duration:
30 months (actually 18 months, self-financing lifetime extension of 12 months)

Pictures:

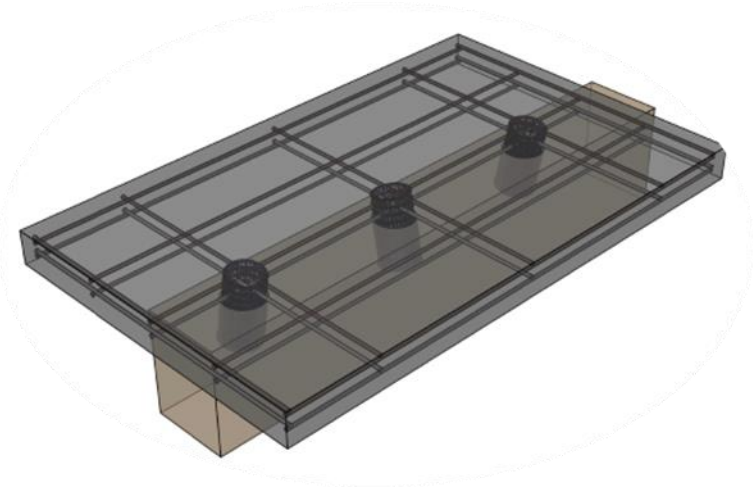
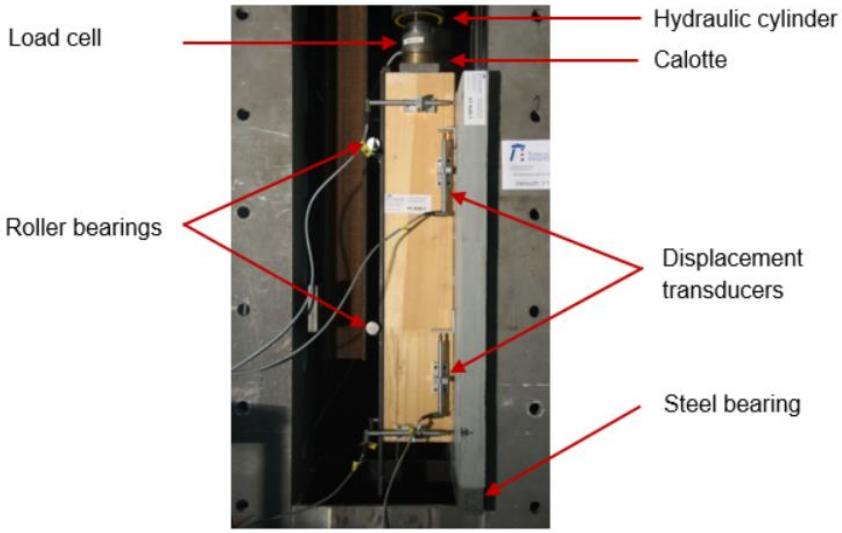


Figure 1: Visualisation of the connection system



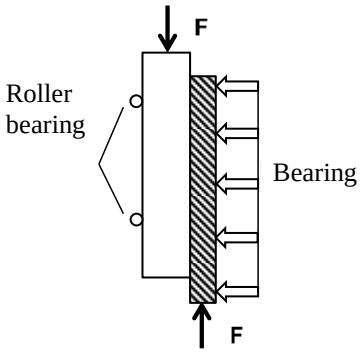


Figure 2: Test setup for push-out test (left) and static system (right)

Figure 3: Shearing of the HPC dowel, shown in each composite part

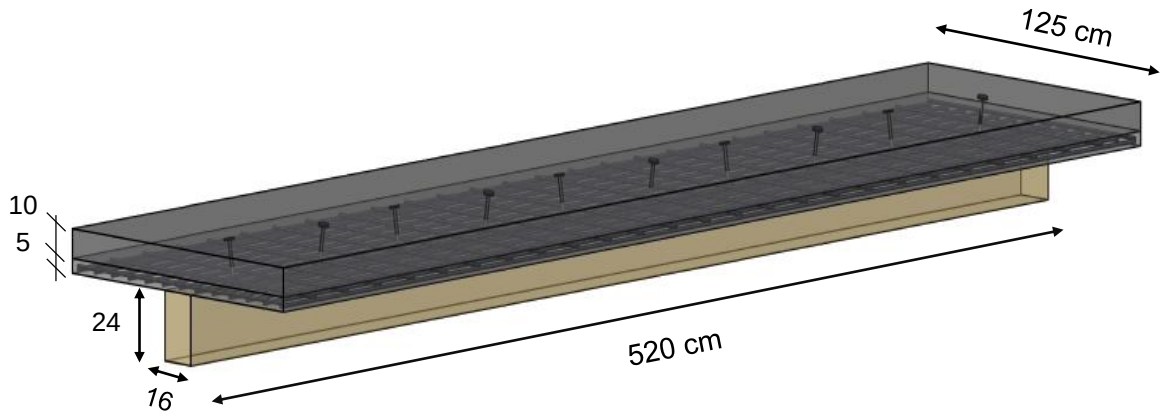


Figure 4: Visualisation of the T-beam for the preliminary test (three-point bending test)

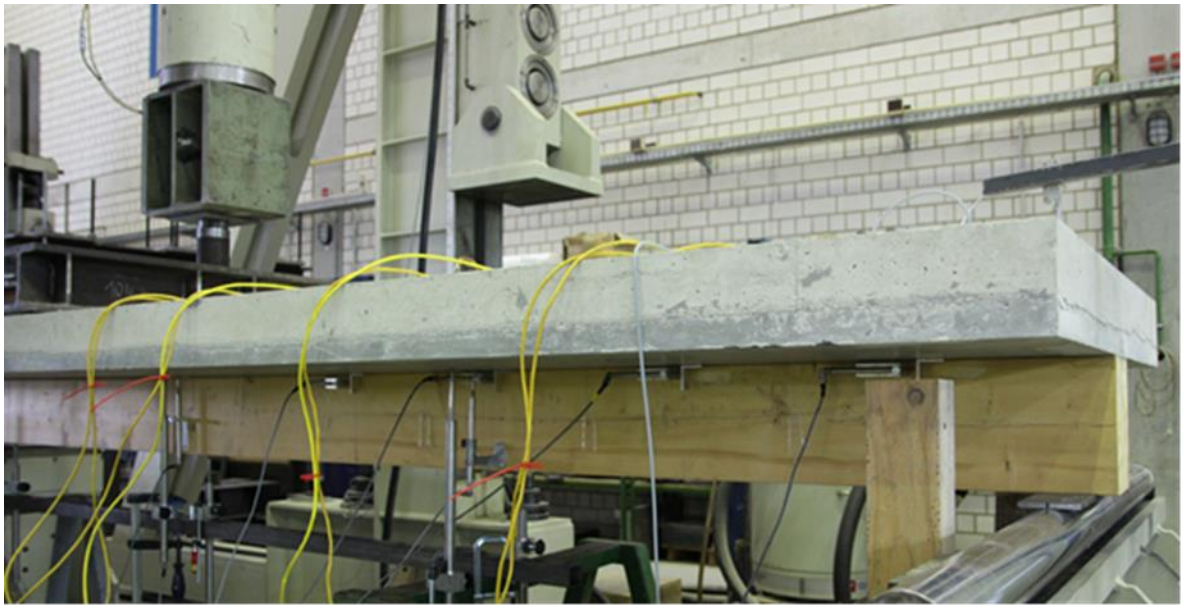


Figure 5: Test setup and measurement of the three-point test

Figure 6: Bending tensile failure of the timber beam in three-point bending test No. 1

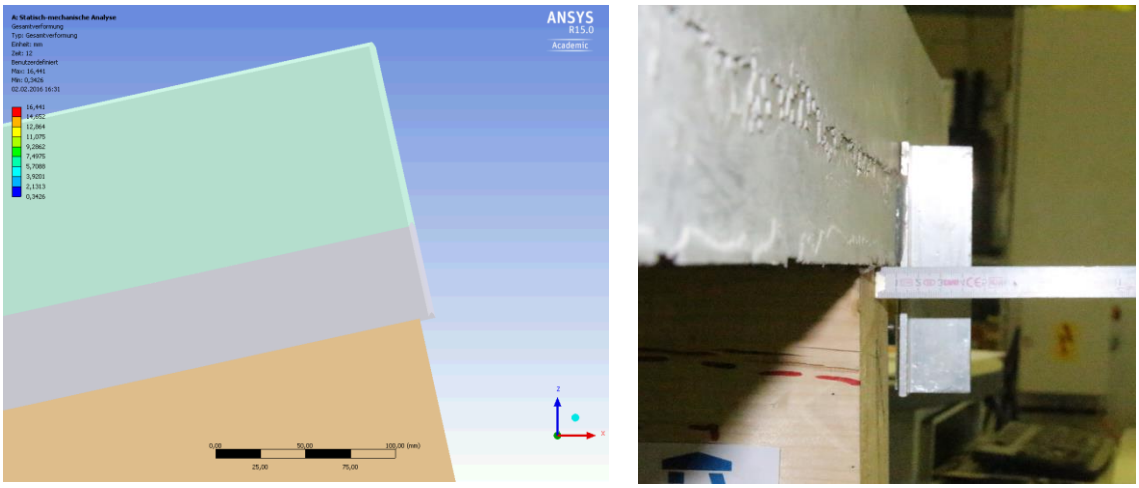


Figure 7: Slip between the two composite parts at the beam end showed in simulation (left) and in test (right)

Picture credits:

All pictures were taken by Department of Civil Engineering, TU Kaiserslautern