Zukunft Bau

Summary

Title

Ceiling system with double bond technique

Motive

In this research project a new type of combined steel bond system which consists of Y-shaped connectors and puzzle teeth has been developed. The main concept involves large span composite beams made of halved steel I-Profile and high performance concrete (HPC) as semi-precast slab, which will be supplemented with in-situ concrete in the finale state. In order to study the load bearing capacity and the deformation behaviours of the shear connector, push-out experiments, comparative FE-simulations and verifying large scaled experiments (3-point bend experiments) were conducted.

Research project aim

As a first step, the load bearing capacity and the deformation behaviour of the shear connector were studied in push-out experiments, where the roughness of the HPC-chord surface, the transverse reinforcement's quantity and the construction state were varied. Two test setups were utilized. For the test specimens without transverse reinforcement, only a concrete split occurred, whereas transverse reinforcement led to a combined failure of concrete cone and split. Furthermore, the experiments showed that the shear connector exhibited a ductile post peak behaviour and a high load bearing capacity in the final construction state.

In the second step, comparative FE-simulations have been performed in order to obtain further insights about the stress in the shear connector and the load transfer. The symmetric push-out experiments were illustrated and simulated in detail. For these, the stress distribution and the plastic strains were mainly observed. In total, the three series of the symmetric push-out experiments were illustrated in the simulations. The qualitative stress distributions and the initial deformations from the FE-simulations were plausible and could be partly observed in the push-out experiments too. It was recognisable that the largest stresses occurred in front of the Y-shaped connectors and the puzzle teeth. The largest plastic strains were observed in the mentioned area and in the sector of the shortest shearing length of the steel puzzle teeth. A quantitative comparison of the load bearing capacity of the experiments with the simulated models is not very informative yet, because the material properties of the FE-models still have to be adjusted. Still, the deformation behaviour and the initial stiffness of the experiments match the ones in the simulated models.

Following the FE-simulation, two large scale experiments (3-point bend experiments) were prepared and performed, whereby the construction state as well as the final state of the ceiling system were studied. The dimensioning of the composite T-beam was set based on the results of the push-out experiments to obtain a failure in the shear joint, so that the obtained results in the push-out experiments can be verified with the large-scale experiments.

As expected, the load bearing capacity as well as the initial stiffness of the composite T-beam in “final state” were approximately three times higher than those in “construction state”. In “final state” combined failures occurred in the compressive concrete zone and in the shear joint as concrete cone, while a sudden failure of the compressive concrete zone was observed in “construction state”. The slip measured at the edge of the composite T-beam in “final state” reached a maximum value of approximately 8 mm and verified consequently the large deformation capacity of the shear connectors. The evaluation of the measured strains in “final state” showed that a flexible bond in the shear joint could be achieved by high levels of load. In the “construction state” the slip was minimal and the concrete slab was completely in the compressive zone. Because of the thin HPC-chord (30 mm), this composite T-Beam failed in consequence of exceeding the concrete compressive strength.

Conclusion

For the targeted double bond, a new type of shear connector was developed. The studies showed that the shear connector exhibited a ductile post peak behaviour and a high load bearing capacity in the final state. The results achieved can be used as a base for an engineering model, which provides an economic and a safe design of this bond system. Furthermore, the studies showed that the shear connector had a brittle behaviour in the construction state. It is to be studied in future researches how the ductility of the shear connector in the construction state could be improved. The bond system has the potential for further optimization.

Basic data

Short title: ceiling system with double bond technique

Researcher / project management:
Prof. Dr.-Ing. Jürgen Schnell

Total cost: 204,300 €

Federal subsidy share: 116,640 €

Project duration: 24 months

FIGURES/ FIGURES:

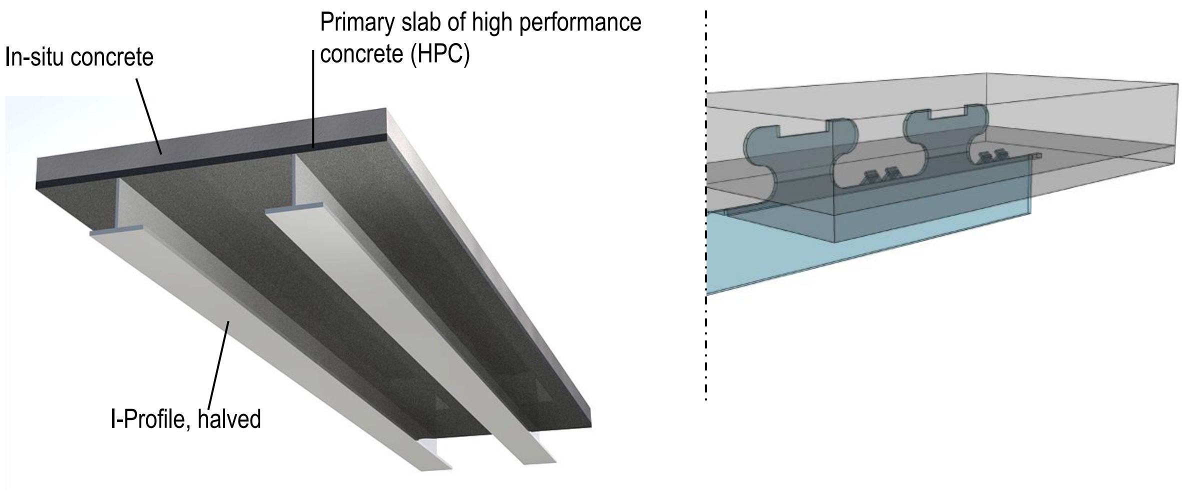


Figure 1: Representation of the ceiling system with in-situ concrete, high performance concrete (HPC) and steel beam: construction concept as PI-slab (left) and a cut-out of the bond system (right)

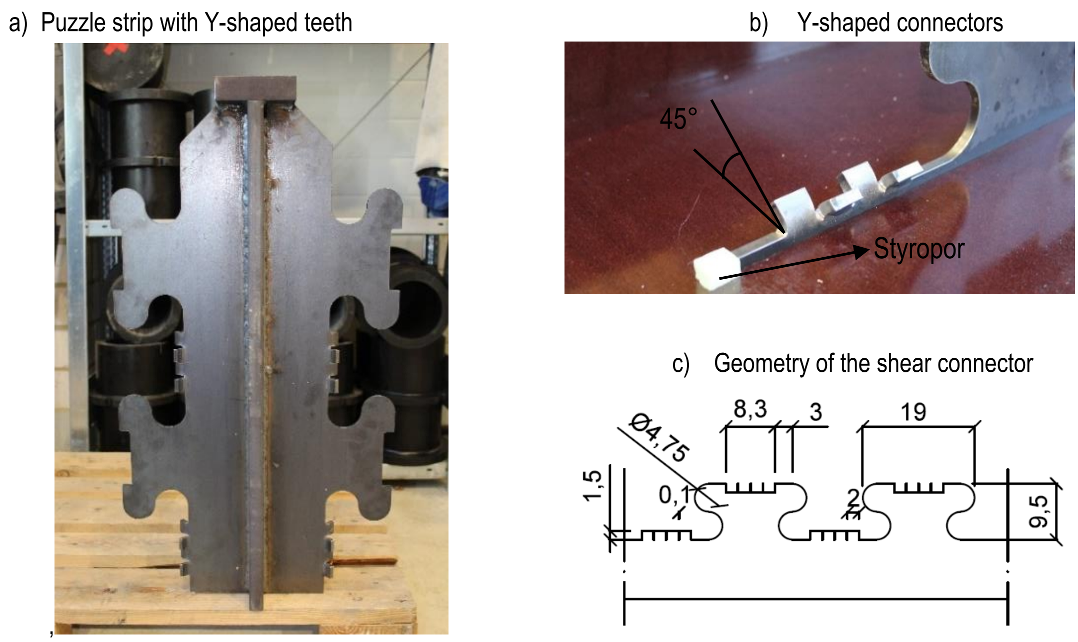


Figure 2: Applied shear connector

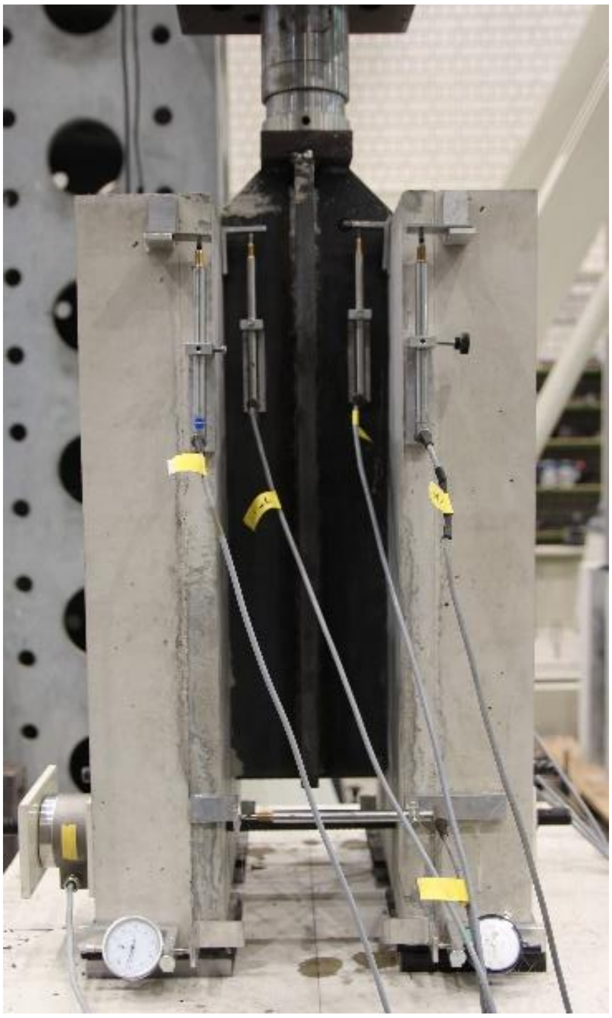


Figure 3: Test setup for the classic push-out experiments

Figure 4: Concrete cone failure on the outside (left) and on the inside (right) of the experiment V1-Sym-End-3

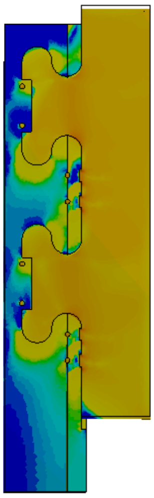
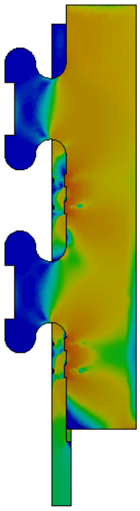
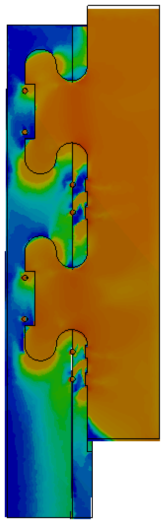
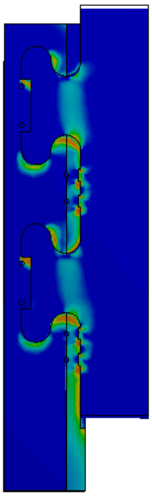
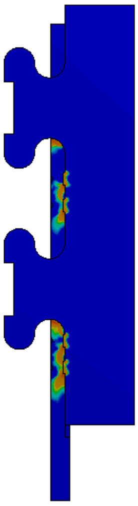
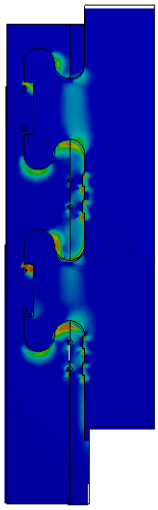
Series	Final state	Construction state	Shear Joint
Equivalent stresses			
Equivalent plastic strains			

Figure 5: Equivalent stresses and plastic strains occurring in the simulated models

Figure 6: Test setup, 3-point bend experiment

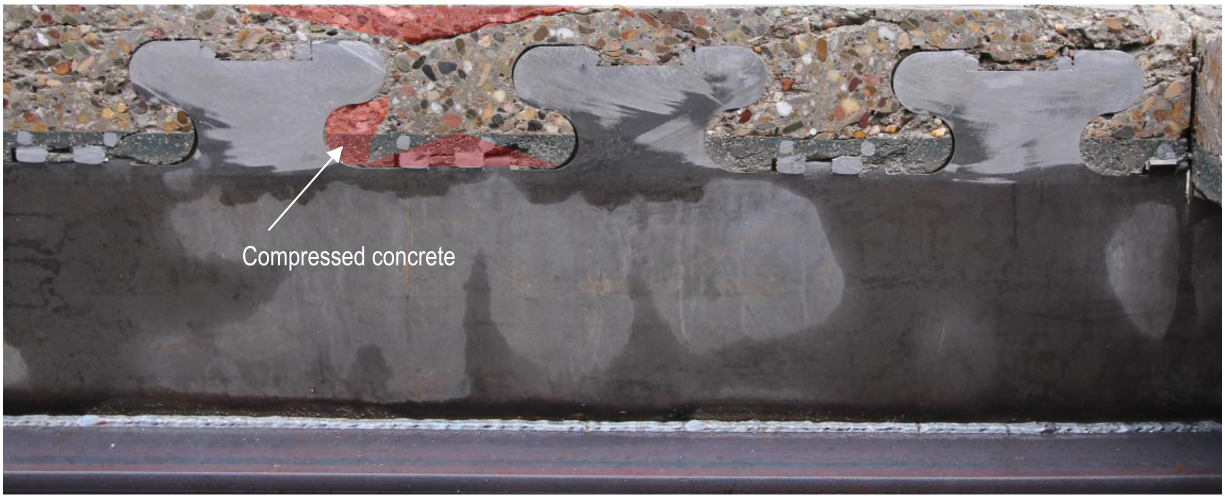


Figure 7: Cut-out of the saw cut along the shear joint of “final state” specimen

Figure credits:
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