Zukunft Bau

Summary

Title

Design and construction of self-floating flood barriers in concrete sandwich construction: "self-erecting flood barriers"

Motive

The European Flood Risk Management Directive, which entered into force in 2007, sets an EU-wide legal framework to reduce adverse impacts of flood events on human health, economic activities, the environment and cultural heritage. In the meantime, the Directive has been transposed into national law of the EU-countries. The focus is clearly on the precaution, which also includes the building security.

This Building precaution includes i. a. measures of flood-adapted construction as well as the flood-adapted execution of architect, engineer and handicraft achievements.

A specific task exist in the protection of buildings by self-erecting flood barriers, as they can be used at building entrances, light shafts, entrance of underground parkings, etc. The creation of inner city, temporary storage space on streets and squares for the retention of water from local heavy rainfall events represent also a challenge, for which solutions are to be offered within the scope of this project.

Within the framework of this project, sandwich elements with polystyrene core and concrete cover layers are to be designed to dam up a height of up to 100 cm an to bear all possible effects incl. trafficability. Development goals include as well system reliability, robustness and durability.

Research project aim

Flood-proof construction is a task that is of great importance in terms of safety and economics in many regions of Germany. Additional challenges arise from the statistically significant increase in local heavy precipitations, which occur with little warning time.

The construction of the available mobile protective equipment requires a large number of trained workers and enough warning time. The experience has shown that, in the case of local heavy precipitation without warning the necessary required extent of manpower is not available. Currently known self-floating systems don’t fulfill the requirements of robustness (trafficability) and durability.

The use of concrete as in the construction industry enables cost-effective solutions with a long service life. High-performance concrete allows filigree constructions with high density.

For these reasons, a completely new design principle of flood barriers was pursued within the framework of this project. The main focus was on system reliability, robustness and durability with low production costs and low maintenance requirements as development goals.

The protective elements should float automatically and make a power supply that is possibly interrupted in the flood event unnecessary. They should also be functional regardless of the workload of the emergency services. In the prototype design many aspects like a non-slip profiling of the surface, snow clearance, protection against dirt and the slight flushing of the system for cleaning purposes after the occurrence of floods, etc. were carefully observed.

Sandwich elements with thin cover layers made of high-performance fine-grained concrete have been known in several previous research works. The application of sandwich method in construction of water barriers is completely new. The developed barrier with the watertight concrete joint (patent no. 102017130818, innovator: Kasem Maryamh) is without precedent in the concrete construction.

In the first step, an extensive research on self-floating flood barriers and their application fields as well as some practical examples were carried out. At the same time a design principle was developed and a pre-dimensioning was created. The load cases and the material properties have been determined.

In addition, the load bearing capacity and the deformation behavior of the barrier as a sandwich component on geometrically simplified specimens were investigated. For this purpose, the core structure and its strength, the reinforcement content and its form were varied. At the same time, test specimens in a carousel-like test stand were run over more than 25,000 rotations with a rubber-tyred wheel under normal road traffic loads (half axle load of a passenger car).

The knowledge gained in the experiments was used to build a prototype. Hereby, the Barrier together with the concrete joint were made in the original scale with a width of 20 cm. The prototype was investigated in passive and operational states under quasi-static and dynamic loading.

To verify the functionality of the developed system, a 20 cm wide of the developed system (barrier and joint) was installed in a specially designed test facility. The test facility consists of a steel frame, which was waterproofed from the inside with Plexiglas panels.

The experimental investigations have proven that the developed self-erecting flood barrier system has a sufficient load-bearing capacity both in passive state under traffic loads and in erected state under water pressure.

Conclusion

As a contribution to the limitation of flood damage, a self-floating flood barrier was developed at the TU Kaiserslautern, which fulfills all requirements in terms of functionality, durability and load-bearing capacity. The construction consists of a sandwich element with top layers of high-performance concrete and it is characterized by the use of a maintenance-free, watertight concrete joint, which transmits all arising forces in every position. The system is to be further developed after completion of the project and brought to a pilot application on a river in Rhineland-Palatinate.

Basic data

Short title: self-erecting Flood barrier, Flood protection, UHPC

Researcher / project management: Prof. Dr.-Ing. Jürgen Schnell (TU Kaiserslautern), Kasem Maryamh M.Sc. (TU Kaiserslautern)

Total cost: 156.058,15 EUR

Federal subsidy share: 89.523,06 EUR

Project duration: 24 months

FIGURES:

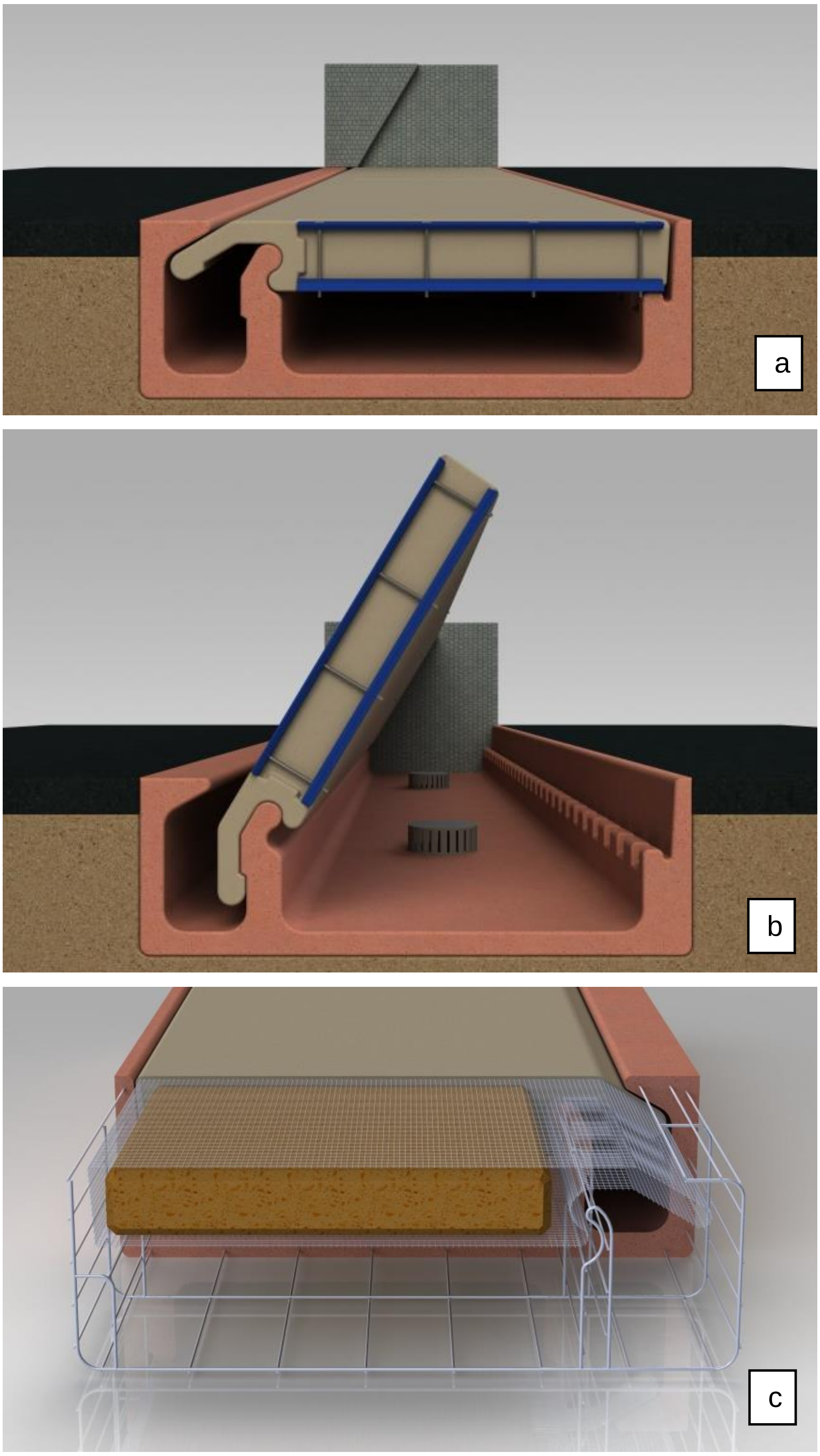

Figure 1: a) lateral view of the system at passive state. b) lateral view in the erected state. c) Styrodur core and the position of the reinforcement or the micro-reinforcement

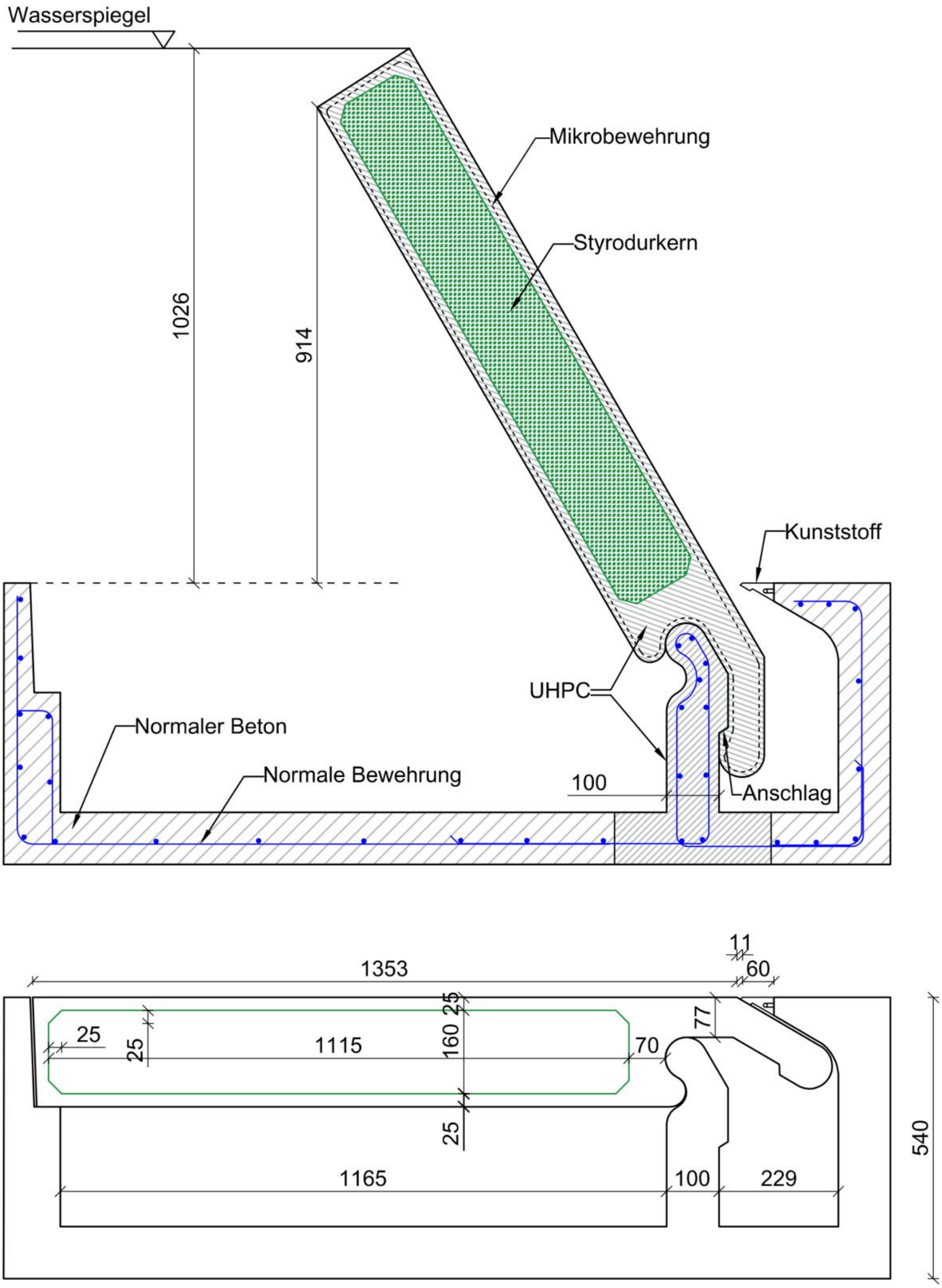

Figure 2: Dimensions, the reinforcement and marking of UHPC and normal concrete

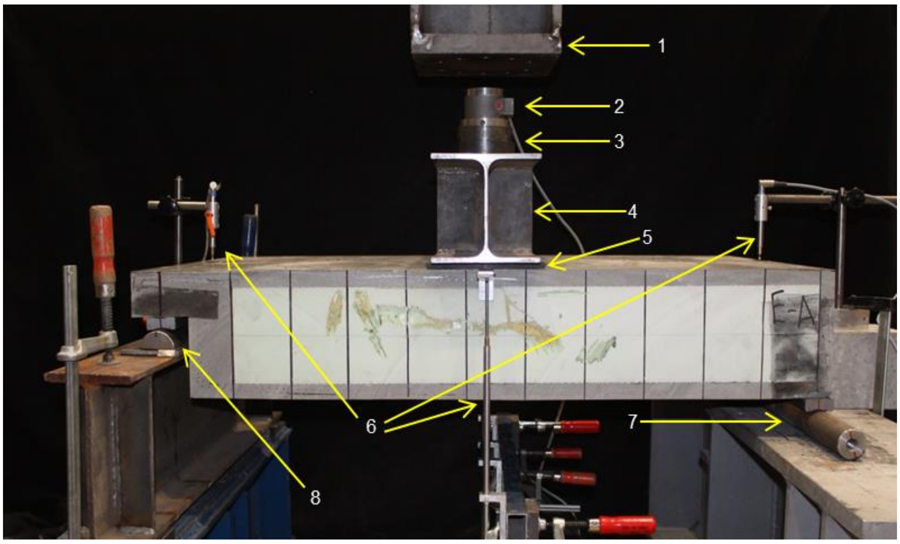

Figure 3: Experimental setup of the bending test of the geometrically simplified samples

1 steel girder (connected to test cylinder), 2-load cell, 3-calotte, 4-steel beam (for force transmission), 5-rubber mat, 6-extensometers, 7-roller support, 8-fixed support

Figure 4: Attempt at a carousel-like test stand

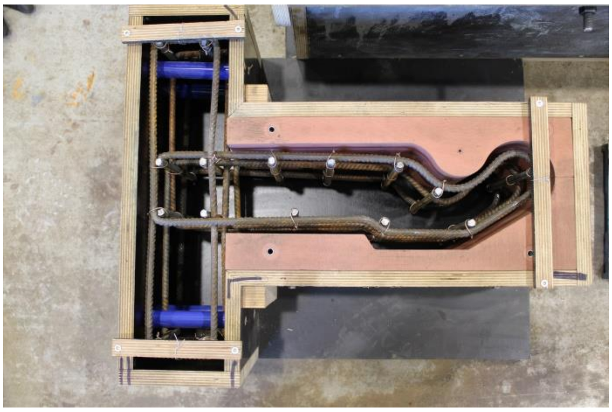

Figure 5: Formwork of the prototype (foundation) with the reinforcement

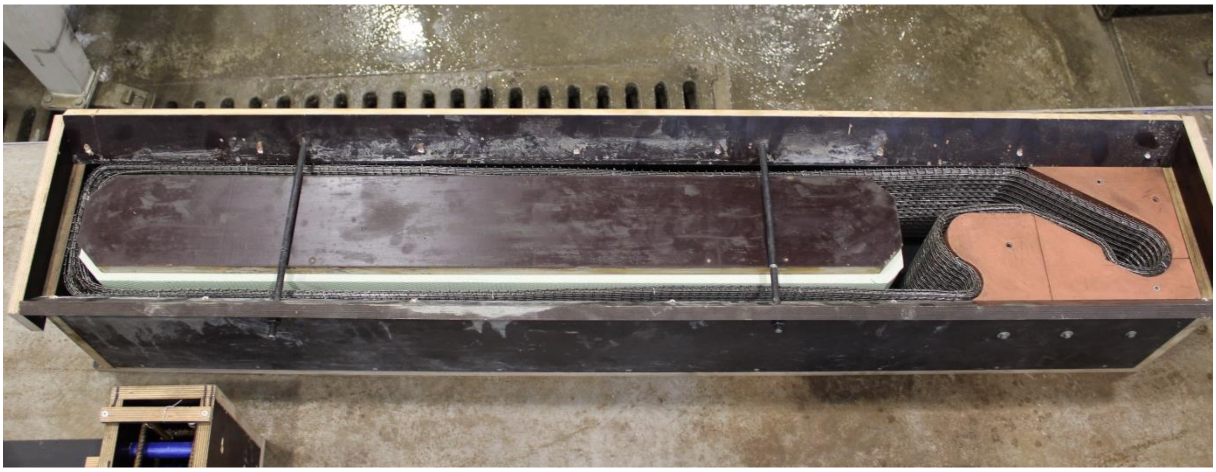

Figure 6: Formwork of the prototype (barrier) with core, micro-reinforcement

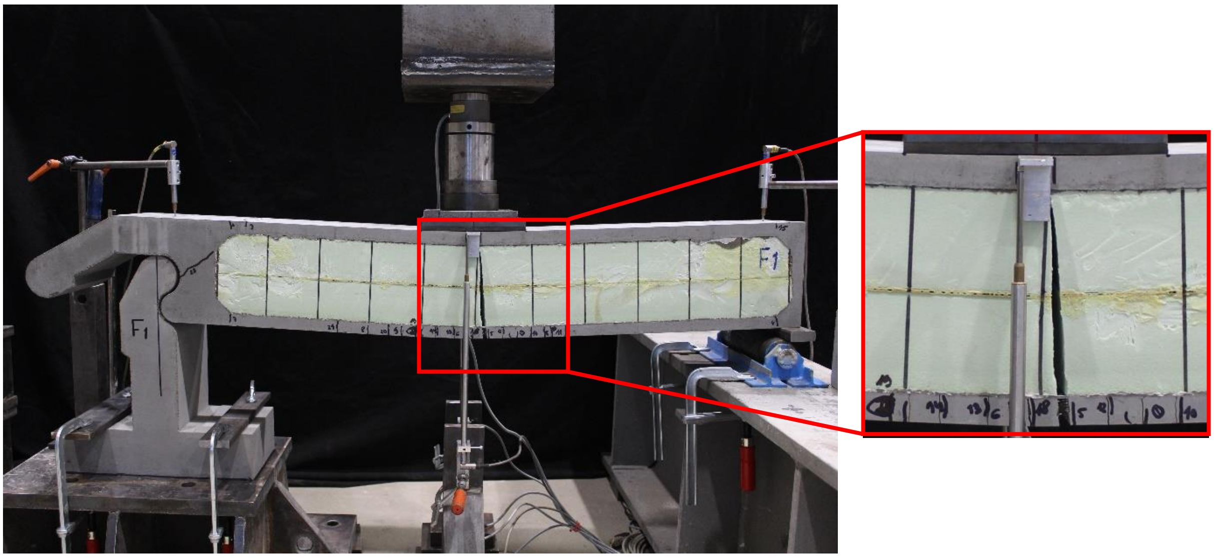

Figure 7: testing of the prototype at passive state, failure of the reinforcement at the lower cover layer in the middle of the field

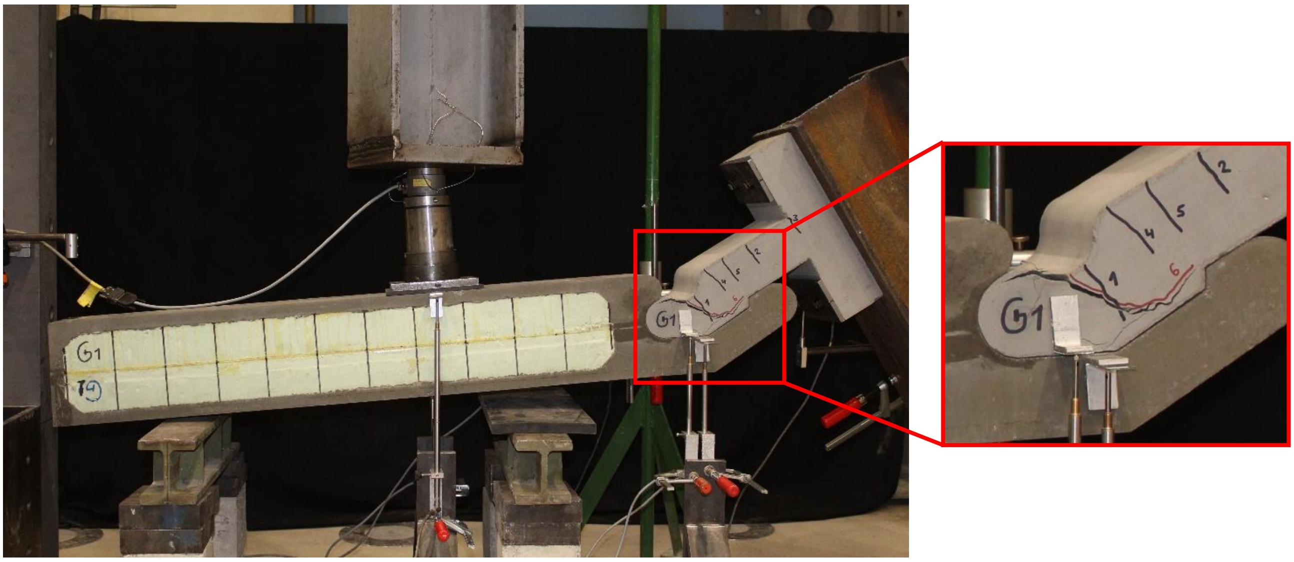

Figure 8: testing of the prototype in erected condition, failure of the adapter part (foundation)

Figure 9: top) test condition rising water level; bottom) test condition water in a max. accumulation height

Figure credits: All Figures, Department of Concrete Construction and Structural Design, TU Kaiserslautern