Zukunft Bau

STRUCTURE SHORT REPORT

Title

Development of a modular, flexible and mobile accommodation unit

Initial situation

Modular construction - a construction method that combines the individual elements according to the modular principle and allows to create complex geometric structures. This principle offers an opportunity to meet the demands of today's rapidly growing cities. Individual modular elements, which can be flexibly exchanged or added to at any time, create a convertible accommodation unit that can be adapted to any surrounding structure. While most people associate the "container construction" with emergency accommodation, architects have discovered the potential of this construction method long ago. In comparison to the initial interests of saving material and time, modular building is evolving into experimental and innovative architecture.

Subject of the research project

In the current research project, a new variation of the modular construction with sandwich elements in monolithic design was developed, whereby the thin cover layers consisted of textile reinforced concrete. In preparation for the research project, the most important basics like the preparation of a spatial concept and building design, the determination of the dimensions of the building as well as the materials to be used were compiled in detail.

Due to the filigree, monolithic construction method, a concrete composition had to be developed which, in addition to its self-compacting properties, also exhibits slight shrinkage shortening. Furthermore, it has a flowable consistency over the entire concreting period, deaerates itself, does not tend to segregate and is also characterised by a high compressive strength of 130 – 150 N/mm².

A significant component of the experimental investigations was the reduction of deformations and thus the development of a suitable design for the prestressing of the textile reinforcement. The maximum prestressing possible to apply was determined in uniaxial tensile tests before the component investigations started. The key statement of this test series was that the maximum prestressing does not correlate with the maximum tensile stress of the reinforcement, but with the slip out of the reinforcement from the clamping device. Based on this knowledge, an optimized prestressing system was developed for the different specimens.

In the first component tests, the general load-deformation behaviour of the concrete slabs under bending stress was investigated. The focus was on the analysis of the effectiveness of the prestressing and the installed textile reinforcement in comparison to the non-reinforced concrete slabs. The use of carbon fiber mats resulted in an extremely ductile load bearing capacity. In addition, the favourable influence of the applied prestressing on the load-deformation behaviour was confirmed.

Afterwards, bending tensile tests were carried out with the sandwich elements in order to determine the difficult load-bearing behaviour of the composite component and its failure modes. In these test series four failure modes were determined. The local shear force failure at the load introduction areas was always decisive. Furthermore, the specially manufactured insulation board texture confirmed a good bond behaviour between the individual layers, so that a mutual displacement of the layers only occurred after the decisive shear force failure.

The focus of this research project was on the development of a suitable manufacturing process for the monolithic accommodation unit and the subsequent investigation of the specimens with regard to their load-deformation behaviour and optical appearance.

The construction of the formwork and prestressing system showed that the conception of the corner details requires careful and detailed planning. The required segmentation of the individual components had to be adapted to each subsequent design element so that the internal carbon fibre mats could be pulled out without any problems. In addition to the corner details, the clamping device and the prestressing system also required a precise coordination.

In extensive tests, the load-bearing behaviour of the accommodation unit was finally examined. The deflections were relatively low until the maximum force was reached. The failure of the accommodation unit was caused by a local shear force failure at the load introduction area. As a result of the redistribution in the component, no sudden drop in load could be observed.

In addition to the component tests, the fresh and hardened concrete characteristics of the individual concreting was also investigated. The strength and consistency values met the requirements of a self-compacting high-performance concrete. Furthermore, an extremely low-shrinkage concrete composition was developed.
In the last step, an optical evaluation of the exposed concrete surfaces was carried out. These surfaces proved to be uniform and very presentable. Neither visible cracks nor signs of segregation were observed on the specimens.

Conclusion

The aim of the research project was the development and production of a modular and changeable accommodation unit made of sandwich structures with cover layers of textile concrete. The research project should contribute to the realization of a new experimental approach in modular construction, which represents an economical and high-quality alternative to the already existing design variants. Thereby the accommodation unit should be designed in such a way that the static and constructive requirements as well as the transportability are ensured.
With the research project "Development of a modular, flexible and mobile accommodation unit" a new variant of the modular construction of sandwich elements with thin cover layers of textile concrete in monolithic design was developed. In addition, the flexible design options offered by attachable modules and a minimalist, efficient architecture make it possible to combine innovative design with constructive structural ideas.

Basic data

Short title:
MonoBau

Project management:
Prof. Dr.-Ing. Wolfgang Breit (Technische Universität Kaiserslautern)
Daniel Nyman, M. Eng. (Technische Universität Kaiserslautern)

The research report was funded by the “Forschungsinitiative Zukunft Bau des Bundinstitutes für Bau-, Stadt- und Raumforschung“.
(Aktenzeichen: SWD – 10.08.18.7-16.52)

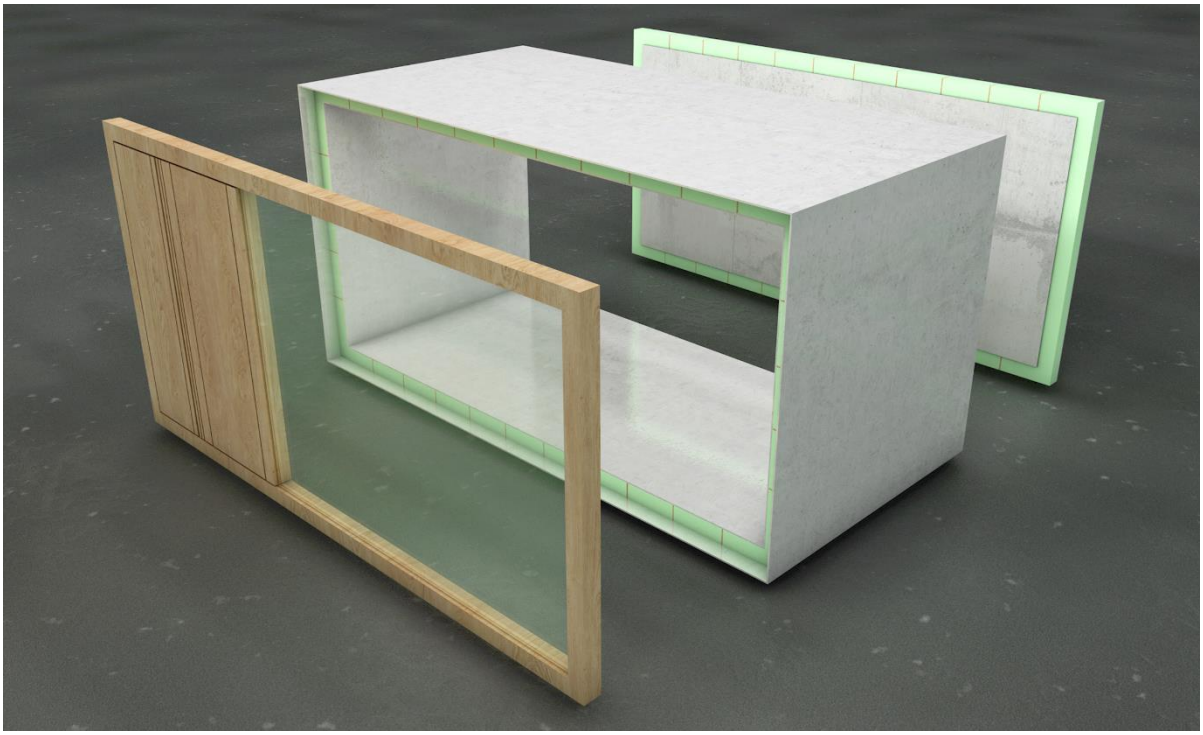
Total costs: 231.831,00 €

Part of the federal funding: 128.348,48 €

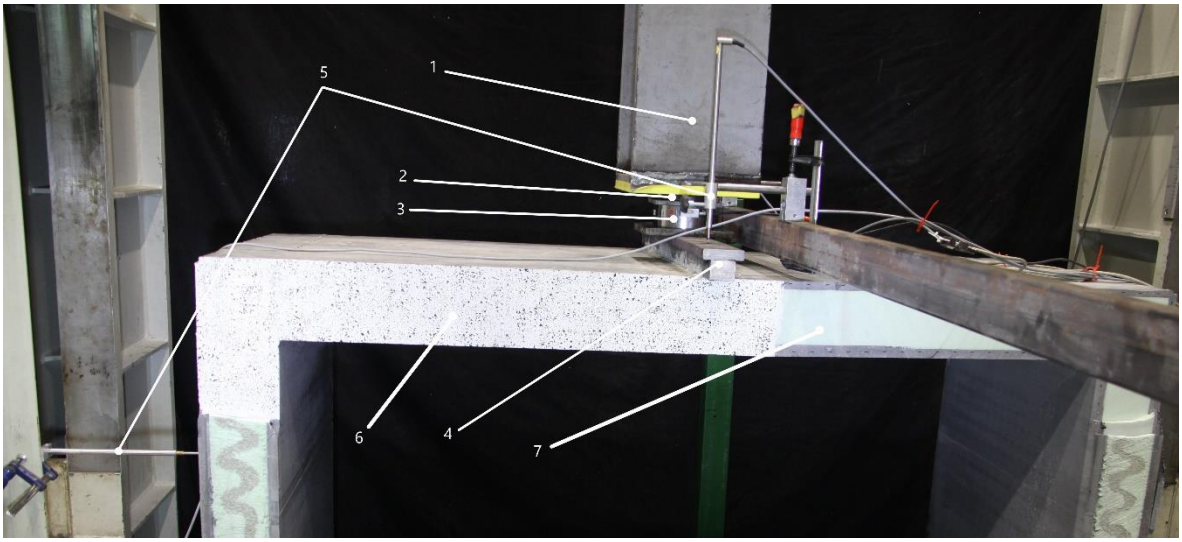
Project duration: 01.12.2016 – 01.12.2018 (24 month)

PICTURES:

Picture 1: Building design (Source: Bayer, D.; Berger, D.: TUK, fatuk)

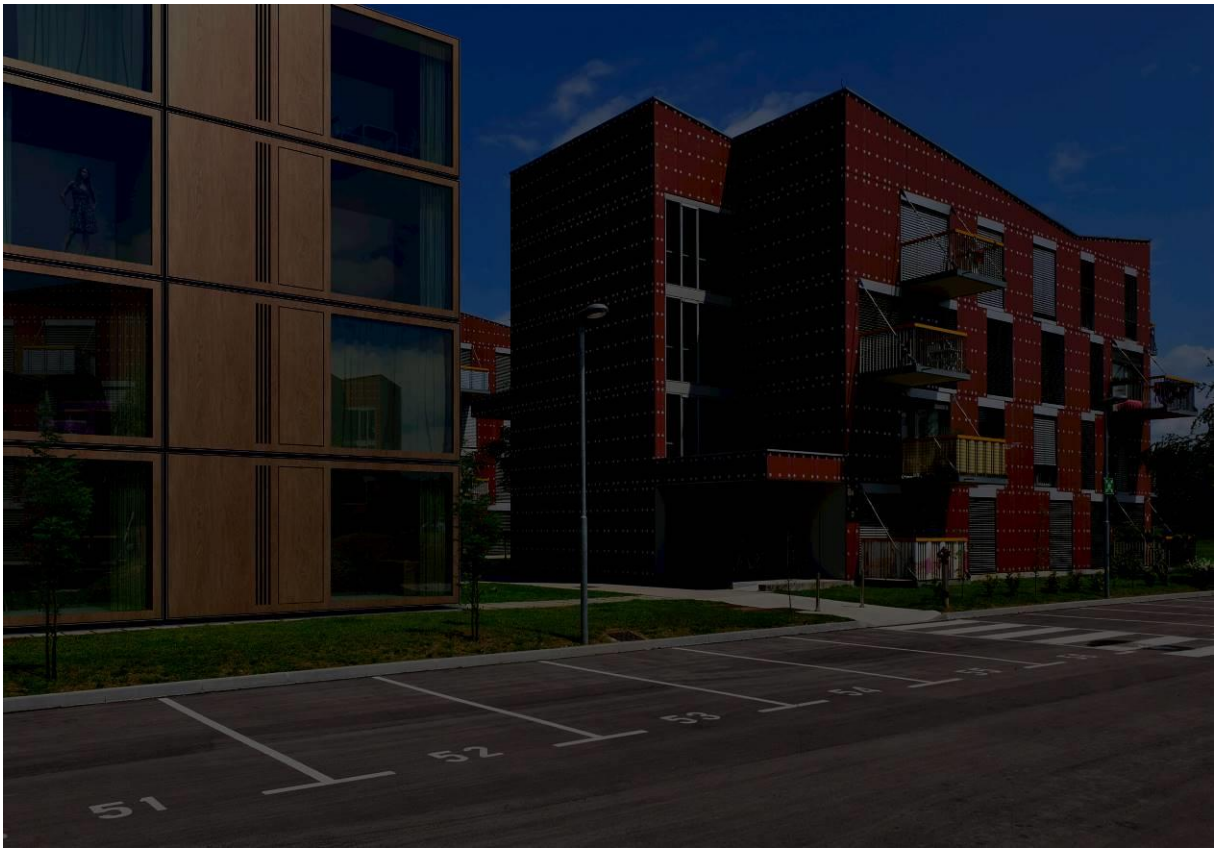


Picture 2: Structural design (Source: Bayer, D.; Berger, D.: TUK, fatuk)



Picture 3: Experimental setup


Picture 4: MonoBau-Unit (Source: Bayer, D.; Berger, D.: TUK, fatuk)



Picture 5: Urban realisation possibility (Source: Bayer, D.; Berger, D.: TUK, fatuk)

Picture 6: Urban realisation possibility (Source: Bayer, D.; Berger, D.: TUK, fatuk)