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EXTREMELY LIGHT AND SLENDER PRECAST PEDESTRIAN-BRIDGE MADE OUT OF CARBON-CONCRETE

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Carbon-Concrete is an innovative composite material which has the won german “Zukunftspreis 2017”. It uses mesh-like carbon textiles reinforcements and a fine-grained concrete as basic materials. Unlike steel, Carbon is not susceptible to corrosion, thus it is possible to minimize the concrete cover to only a few millimeters. As a result, slender concrete constructions can be built, meeting the needs of modern architecture with both economical and environmental advantages.

Existing bridges made of steel-reinforced concrete often show damages induced by the corrosion of the reinforcement. The concrete covers of those constructions were designed in accordance to former standards, but are too small with regard to the required corrosion protection of steel reinforcement against carbonation and chloride ingress, leading to cracking and spalling of the concrete. These damages cause optical detractions on one hand, and on the other a reduced load-bearing capacity of the construction. The consequence is that these structures have to be improved by cost-intensive actions or replaced entirely by new structures.

To avoid such high-priced restoration work new construction concepts had to be found. One promising solution is the use of Carbon-Concrete for bridges. The alliance of the developing company solidian, Knippers Helbig, Max Bögl and the Institute for structural concrete of the RWTH Aachen University proved the applicability of the innovative material. In 2015 the first carbon-reinforced precast bridge in the world was built successfully (Fig. 1).

Fig. 1. TRC pedestrian Bridge in Albstadt, Germany (picture: solidian)

The pedestrian bridge has a total length of 15,55 m and is designed as a trough. The form of the walls follows the stress. Consequently the textile reinforcement doesn’t need to be staggered. The highest point of the walls is 1,17 m (Fig. 2). The cross-section of the construction is a 294 cm wide concrete U-beam, reinforced with one and two layers of the carbon grid. The whole weight of the bridge is 14 tons.

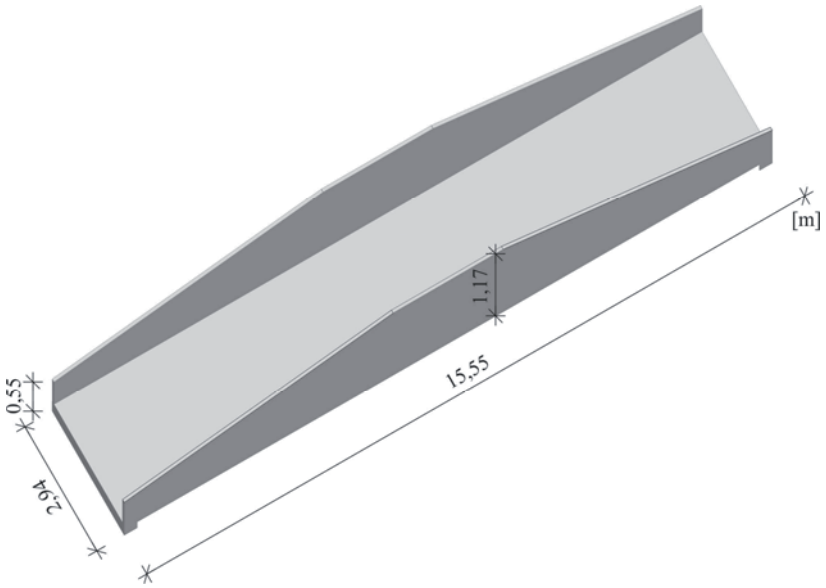

Fig. 2. View of the TRC Bridge

Since textile-reinforced concrete is not regulated by any standards in Germany today, an individual approval of the construction by the building authorities is required. For this purpose, an extensive testing program was carried out at the Institute of Structural Concrete of the RWTH Aachen to assess the load-bearing capacity of the carbon concrete bridge. Based on large-scale test specimens with cross-sectional dimensions of the original scale, the load-bearing behavior, the length of the overlaps and anchoring of the textile reinforcement and also the punching bearing capacity were examined. The attempt of the bridge in longitudinal direction was of particular importance. For this, the bridge was prepared a second time and loaded in a three-point bending test until the fraction entered. The testing force was introduced into the plate near the trough wall via two line loads. A convincing load-bearing behavior could be observed in the serviceability limit state. In this state, the deformation of the 15,55 m long bridge was only 5 mm in the middle. The reason is the stiff U-shape of the cross-section. Depending on the length of the bridge, the height in the middle of the bridge needs to be adjusted to achieve the same little deflection. The breaking force in the experiment was F_{max} = 643 kN, which corresponds to a breaking moment of $M_{u,max}$ = 2335 kNm. Taking into account the partial safety factor γ_c = 1,5 (concrete failure) and the factor α_c = 0,85 (long-term effect), the rated bending moment can be calculated to M_{Rd} = 1029 kNm. In comparison, the effect amounts to M_{Ed} = 1005 kNm. Overall, a global security level of γ_{global} = 2,4 is achieved.

In recent years, textile-reinforced concrete (TRC) has been often applied for small scale structural elements with simple load-bearing behavior and straightforward configurations of textile reinforcements. The example of the 15,5 m long pedestrian bridge with TRC superstructure in Albstadt, Germany, demonstrates that this innovative composite material can also be used for large-scale applications (Fig.3). Tests on the load-bearing behavior showed that next to the required safety-level, even further capacities are available.

Fig. 3. View of the final bridge (picture solidian)