Strengthening of bridges with UHPFRC and memory-steel reinforcement

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Objectives of the project

The objective of this research project is to develop and apply a new "hybrid" strengthening method for bridge decks made of reinforced or prestressed concrete. The strengthening method is based on the combination of ultra-high performance fibre reinforced concrete (UHFB i.e. UHPFRC) and memory-steel ribbed bar reinforcement.

UHPFRC is applied on the existing roughened reinforced concrete bridge deck in a layer with a thickness of 4 cm to 8 cm and memory-steel reinforcement is located in the UHPFRC layer (Figure 1).

The possibility to prestress the memory-steel ribbed bars by heating (i.e. using the memory-effect), has the advantage of relieving the existing reinforcement and reducing crack widths and deformations. The impermeability of the UHFB layer, combined with the prestressing effect of the memory-steel reinforcement, also guarantees that classical bridge water-proofing is not necessary.

Methodology and procedure

First, the new strengthening method will be compared and optimised with linear and non-linear FEM simulations with strengthening methods which are already available on the market, with regard to load-carrying behaviour, costs and sustainability. Parameters such as the reinforcement content of memory-steel reinforcement and the thickness of the UHPFRC-layer will be optimised, taking into account the constraints in the engineering praxis on the building site.

Subsequently, the optimised new strengthening method will be investigated in various lab tests. We plan to perform pull-out tests of memory-steel reinforcement bars from UHPFRC and large-scale tests to verify the load-bearing behaviour of the strengthening method on the cantilever slabs of bridges.

The system behaviour and the practical implementation of the new method will be investigated based on the tests carried out in the laboratory.

Finally, the strengthening method will be applied in practice on an existing bridge within the framework of a pilot application.

Findings for science, practice and the public

The linear and non-linear FEM simulations carried out so far (Figure 2) confirm impressively the main advantages of the new strengthening method with UHPFRC and memory-steel reinforcement: thanks to the prestressing by memory-steel, the existing reinforcement is relieved and the crack widths and deformations are reduced, which has a positive influence on the fatigue of the reinforcement as well as on the tightness and durability. Further laboratory tests and FEM-simulations should confirm these positive effects.

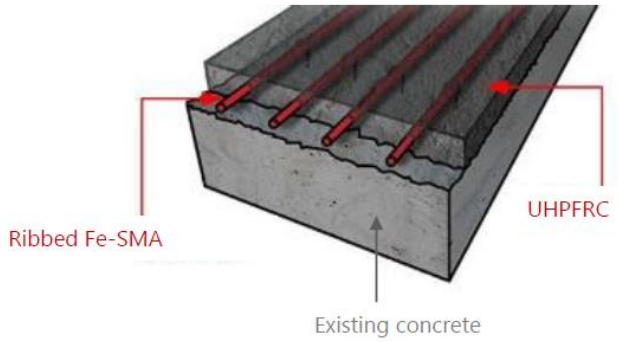
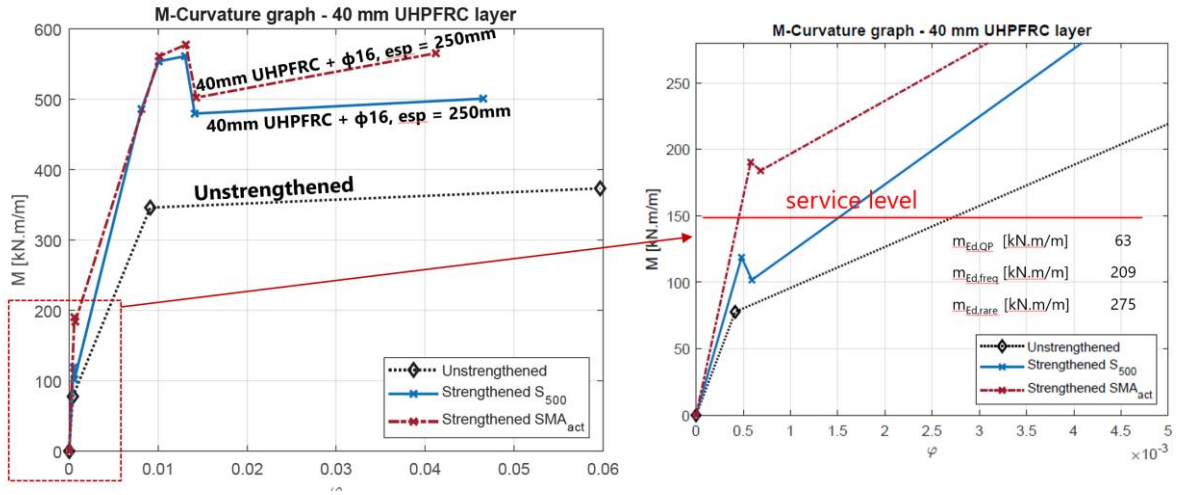


Figure 1: Layout of the reinforcement method with UHFB (UHPFRC) and memory-steel reinforcement (Fe-SMA) on existing reinforced concrete slabs.



Significance for research and practice: innovation

The new strengthening method with UHPFRC and memory-steel reinforcement can enable a significant acceleration of the entire construction process in bridge rehabilitation due to the optimal load-bearing behaviour and good durability and guarantee a significant extension of the remaining service life of bridges.

Figure 2: left: Load-bearing behaviour (moment-curvature diagram) of a rectangular reinforced concrete cross-section without strengthening (grey line), with strengthening by UHPFRC and conventional reinforcing steel (blue line) and with strengthening through UHPFRC and memory-steel reinforcement SMA (red line); right: enlarged view of the load-bearing behaviour in the service condition (serviceability) with significant different curvatures.