7 Main results of project

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Project Phases

The research project was developed from 2018 to 2022 in a total of six project phases:

- 1 – Methods for surveys of steel bridges
- 2 – Analysis of invasive procedures and technical surveys of typical bridge structures
- 3 – Methods for strengthening and renovation of members.
- 4 – Methods for surface treatment and protection
- 5 – Methods for strengthening of joints and connectors
- 6 – Methodology for the assessment of structures with regard to their sustainability

Phase 1-3

In Phase E1, a detailed methodology summarized the general requirements for carrying out structural surveys, material tests and surveys of the coating. The methodology defines qualitatively the scope of the survey, to support informed assessments of bridges and to utilise their potential for continued use.

A total of 73 bridges were inspected in Phase E2. A further outcome was the development of a methodology for quantifying sensitivity of heritage value, so that the heritage value of individual bridge structures could be effectively described and carefully analysed. The Heritage Value Assessment Method (E-P) was used to assess the sensitivity of the heritage value in relation to the invasiveness of the survey methods used.

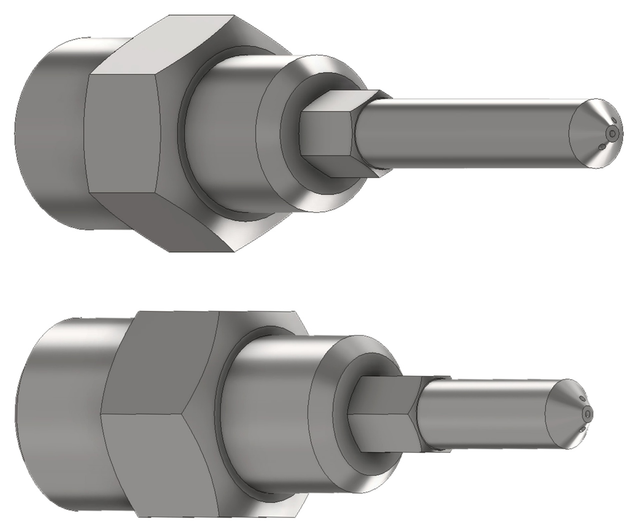
Further, various methods for assessing fatigue life or residual life were developed. A fatigue behaviour prediction tool for degraded steel bridges, FALCom, was developed for fatigue life determination and analysis. The software analyses the fatigue damage of structural elements possibly weakened by corrosion and estimates their residual life.

A very important collaboration was established in Phase E3 with the researchers from EMPA, the Swiss Federal Laboratories for Materials Science and Technology. The SMA technology (shape memory alloys) was verified and applied for the reinforcement of selected elements. A pilot application of the world's first SMA technology strengthening of a bridge was carried out in June 2019. The successful implementation and results of this experiment on a real structure confirmed the great potential of the SMA technology for strengthening historic steel bridges.

The strengthening with SMA should increase the static load capacity and fatigue life of a structure by using its special material property, the so-called shape memory effect. Reinforcement of historic steel bridges has a number of specifics. The irregularity of these structures complicates the possibility of fixing additional strengthening.

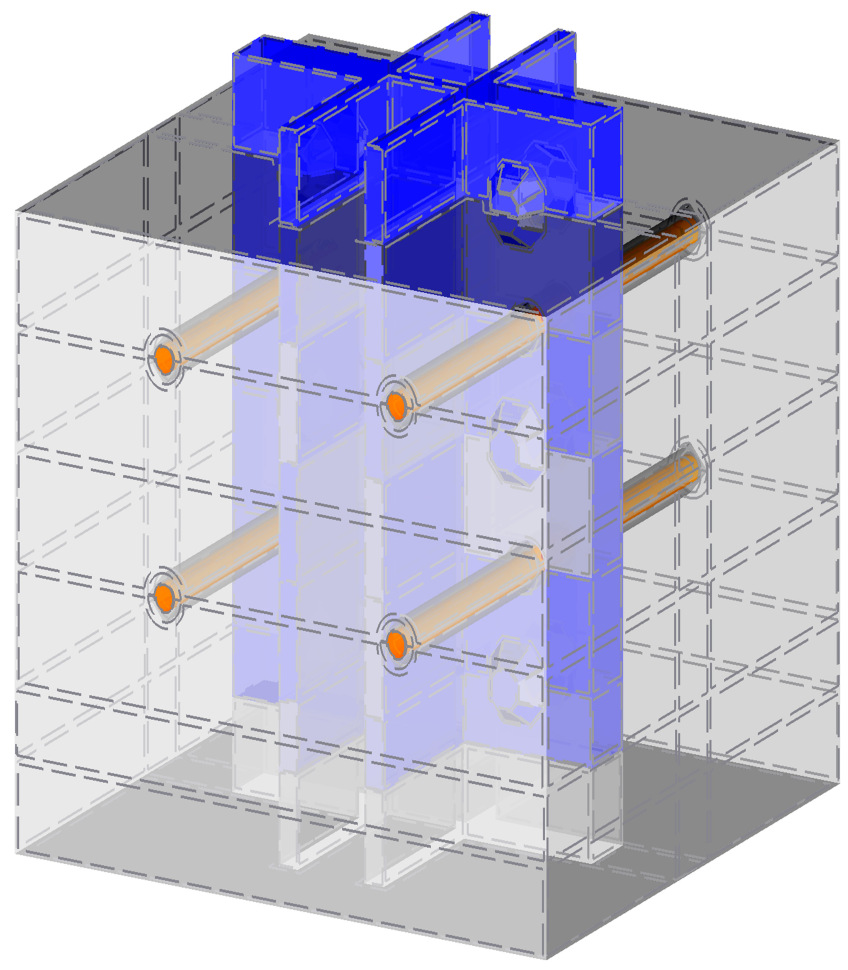
Strengthening crossbeam of historic steel bridge with Shape Memory Alloys

View of activated reinforcement



Innovative nozzle for coating application in restrained conditions

Application of corrosion protection to railing segment of the bridge of Svatopluk Čech



Numerical model of detail of strengthening

Specimen for pilot test samples before concreting

At the same time, due to the technical and cultural value of these structures, it is advisable to keep the necessary structural interventions to a minimum. In the case of strengthening by well-known methods using tension rods, cables or carbon fibre slats, the use of complex anchorage areas is often necessary. In such cases hydraulic presses must also be affixed.

The research also included a laboratory test of strengthening using SMA material. After verification by experiment, the strengthening was applied to the actual construction of the historic steel bridge in Petrov nad Desnou. SMA strips anchored to the crossbeam structure by a pair of angles fixed with HRC bolts were used.

Phase 4-6

In Phase E4, the research was directed towards improving the quality of surface treatment and the application of coating in narrow crevices, which are common in historic bridges. The main result is the utility model UV 34780 – Nozzle for high-pressure water jetting in hard-to-reach areas. Its primary use is for cleaning and debris removal in hard-to-reach areas such as narrow crevices in steel structures. This nozzle can also be used in other hard-to-reach areas when cleaning machine parts and assemblies such as cavities or narrow spaces.

The advantage of the solution lies mainly in the possibility of replacing the nozzle part. The nozzle part can be inserted into a narrow space and blasted directly into the gap. Depending on the depth or width of the slot, the appropriate length of the nozzle section can be selected.

Another important result was a certified technology: Technology of corrosion protection and repair of historic steel structures using combined coatings. The technology provides suitable corrosion protection for smaller steel parts such as demountable railing elements and the decorative parts of historic and technical monuments. It make is possible to apply corrosion protection even on very exposed and mechanically stressed sections of the railings of a steel bridge structure where rapid corrosion attack and loss of lifetime corrosion protection could occur.

The corrosion protection system was designed using a combination of a Zn hot-dip coating with a protective coating system. It is included in the design of the overall corrosion protection system of the railing segment of the Čech Bridge, which is in accordance with the required properties and guarantees a long service life in an aggressive environment. The corrosion protection will thus guarantee the required service life of more than 25 years.

In Phase E5, the research focused on the strengthening of often severely deteriorated support points of steel bridges, using Ultra-High Performance Concrete casing, thereby stopping corrosion and strengthening the corroded section. Both a functional specimen and a utility model have been registered for this strengthening process.

The main result of Phase E6 – methodology for assessing bridges structures with regard to their sustainability is presented in Poster 6.