

# Research project Methods for Achieving Sustainability of Industrial Heritage Steel Bridges

## Heritage bridges

Bridges are part of every route, whether for rail, highway, cycle or pedestrian traffic. They are large structures that complement the landscape or urban character of cities. The second half of the 19th century brought a boom in railway transport. It was at this time that many railway bridges were built. They were stone or brick bridges with small spans. For larger spans, steel bridges were made. Some of them are still in use today. Mostly they are found on local lines or less frequented routes.

In the Czech Republic approximately 400 bridges are protected, four bridges are national cultural monuments and others within urban heritage protection areas. However, age has left its mark on many bridges, particularly in the form of corrosion or the development of cracks. Many valuable metal bridges are not listed and, as a result of their rapidly declining physical integrity, an important footprint of our nineteenth and early to mid-twentieth century industrial heritage is in danger of being irretrievably lost.

These bridges have fulfilled their purpose in terms of their required service life, but by no means all of them can be replaced by new bridges. From the point of view of preserving our industrial heritage, it is, on the other hand, desirable to conserve at least some of them, and to maintain them in a worthy condition.

## Unique structures

In many cases, these are beautiful and unique structures that are no longer commonly encountered in the contemporary world. They are the pride of the Czech bridge engineering from the Austro-Hungarian period and from Czechoslovakia before WWII. The high level of expertise of the engineers of that time, the extent of developed industry, and the quality of work in the production and construction of steel bridges were the prerequisites for the fact that some of these bridges have survived until now. It is, therefore, our duty to preserve this industrial and cultural heritage to an appropriate extent for future generations. However, this means that we must take care of selected representatives of old steel bridges so that they can serve their main purpose – carrying traffic, albeit with some restrictions in usage, for several decades to come. One option, for example, is to transform an inoperative road or railway bridge into a bridge carrying footpaths and cycle tracks.

## Technology

Steel bridges that came into service 100 years ago and earlier do have a different structural design compared to modern bridges. The main characteristic of old steel bridges is the practice of riveting. Individual members that could not be made by rolling were at that time made by riveting. Even the joints in the main structure were riveted. It was not until the second half of the 20th century that welding technology became customarily used in the construction of steel bridges.

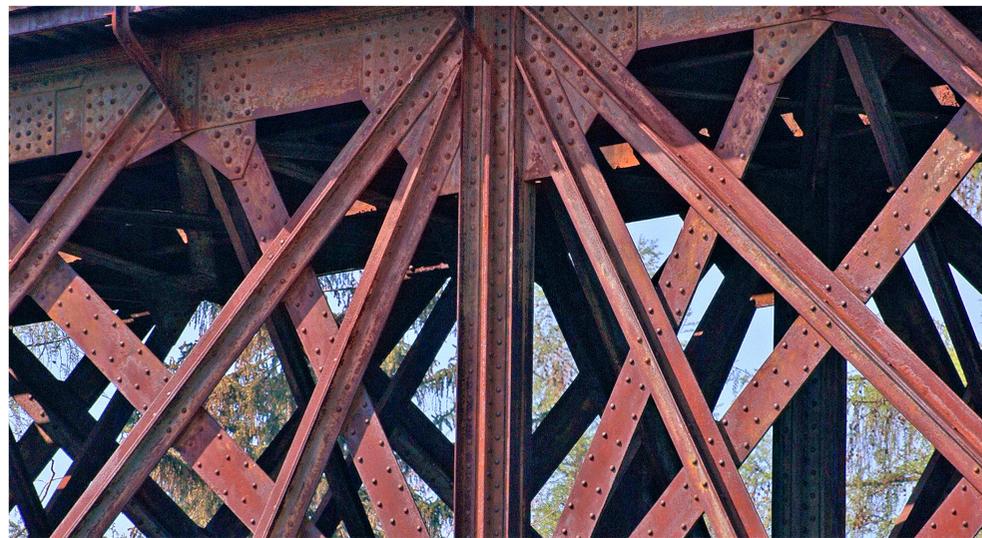
Another specific feature of the old steel truss bridges is the fact that each member has a different cross-section, because at that time maximum savings were made on the amount of steel material used, regardless of labour requirements.



Railway bridge under Vyšehrad



Suspension bridge in Stádlec



Detail of riveted bridge in Mokropsy



Bridge in Skochovice

## The project

The design of steel truss bridges used simplified structural models that were compatible with the computational means of the time. Approximate static models used to deal with statically indeterminate structures contained safety margins that can be used efficiently today. Similarly, we can better describe the interaction of the individual load-bearing elements of a steel structure, which was impossible to do until recently.

In order to maintain the functionality, safety, and protection of these structures facing increasing traffic volumes, it is necessary to develop new methods of survey, assessment, and strengthening of these structures. Therefore, from 2018 to 2022, the Ministry of Culture of the Czech Republic supported project DG18P02OVV033 Methods for Achieving Sustainability of Industrial Heritage Steel Bridges.

In cooperation with the National Heritage Institute and the operators of railway and road infrastructure, the project developed methods and technologies for the surveying and assessment of historic cast iron and steel structures, with a focus on failures due to corrosion and fatigue. Non-invasive and reversible strengthening procedures for elements and connectors, new technologies for surface treatment of historic bridges, and innovative corrosion protection systems using nanotechnologies were developed. Technical inspections of steel bridges were carried out as part of the project, following the results of the comparative mapping of industrial heritage. Subsequently, the results of the project were applied in pilot case studies of typical existing bridges. The multidisciplinary project is based on the cooperation of leading experts from the Faculty of Civil Engineering, Faculty of Architecture (including the Industrial Heritage

Research Centre), Faculty of Mechanical Engineering, and the Klokner Institute of the Czech Technical University with leading experts from the National Conservation Agency and representatives of operators (ŘSD ČR, SŽ and TSK Praha). The achieved findings are being applied not only in construction practice, but also in university lectures and in the lifelong education of civil engineers. The results are verified on existing steel bridges. The target group includes experts in the field of heritage structure protection, designers, construction companies, employees of the responsible authorities, and students at secondary schools and universities. The critical catalogue herein presented is the result of this five-year period of research, and recapitulates both its results and the state and outlook of historic riveted bridges in the Czech Republic.