9

No. 04 – Červená nad Vltavou – railway bridge

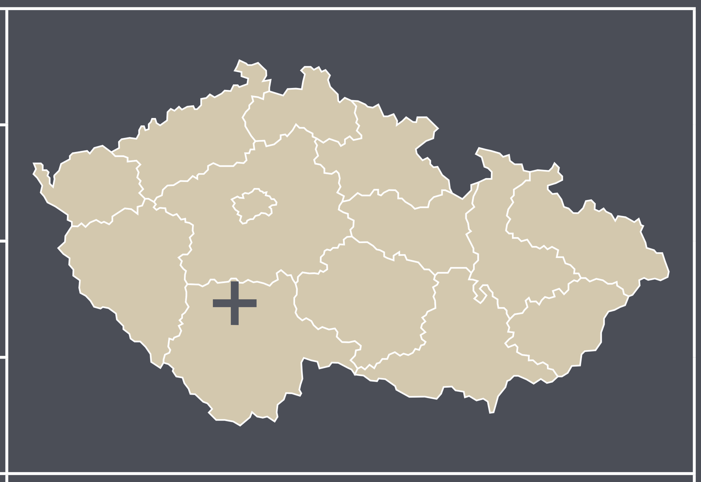
railway truss girder bridge

South Bohemia Region, Písek district

cad. territory Červená nad Vltavou

cultural monument

TÚ 1811[1], DÚ 14[2], evd. km 41,791



49°22'54.42"N 14°15'15.71"E

[1] TÚ – Track section, [2] DÚ – Track definition section

CTU

CZECH TECHNICAL UNIVERSITY IN PRAGUE

View of the bridge from the northwest

History

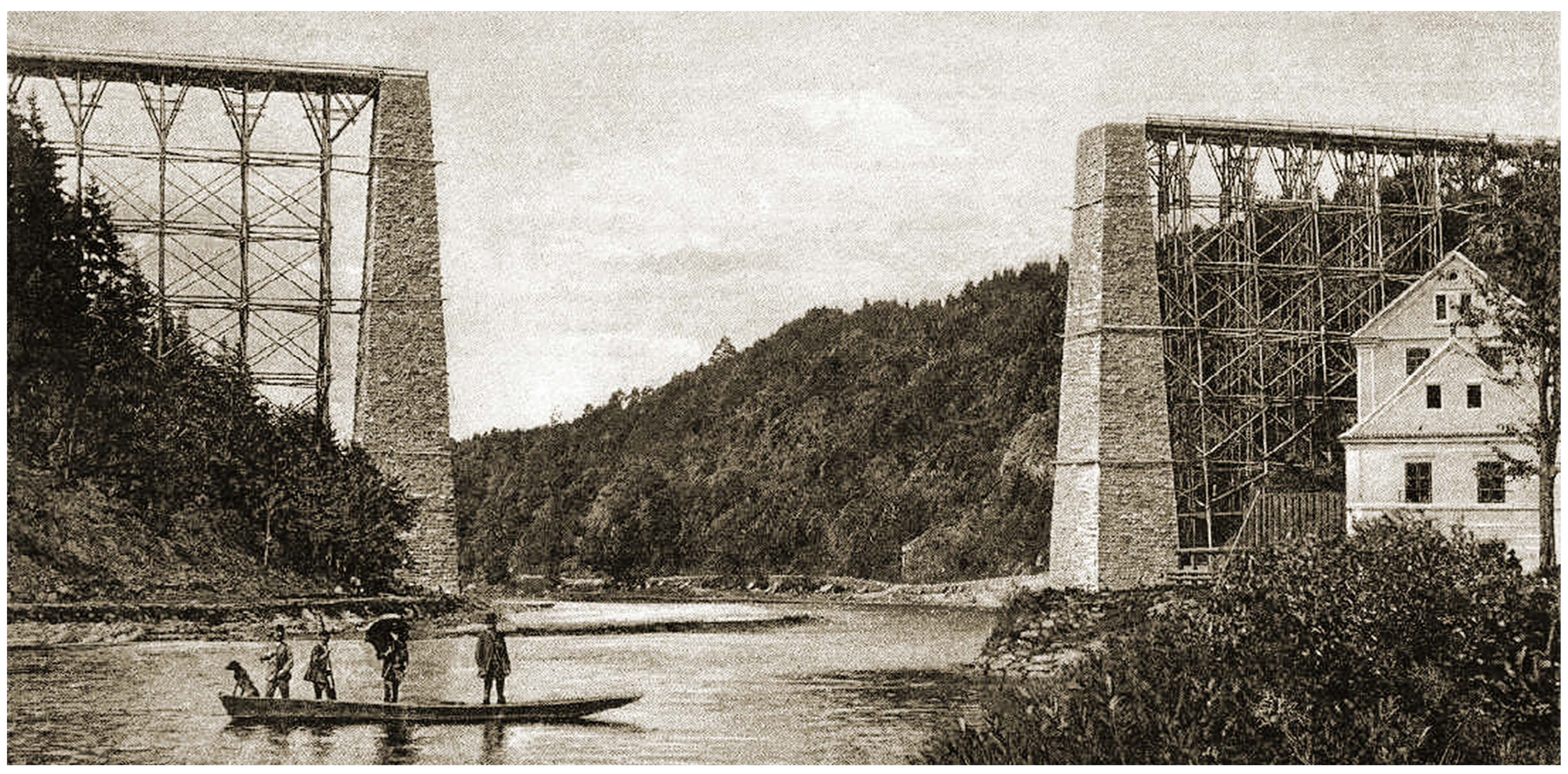
The railway steel truss bridge over the River Vltava (Orlík reservoir) on the Tábor– Písek line is currently the tallest railway bridge in the Czech Republic and was the first railway bridge in Bohemia built using a scaffold-free assembly. The bridge over the deepest part of the Vltava valley carries the single-track railway line. Construction of the bridge began in 1886 and was completed in 1889.

The five span bridge has a total length of 284.2 m. The first and fifth spans are stone arch structures and the second to fourth spans are steel semi-through trusses. In the second to fourth spans there are steel truss structures with spans of 3 × 84.4 m. The main riveted trusses are quadrangular systems with verticals and sub-verticals. The trusses have a constant height of 9,87 m and are at an axial transversal distance of 5,05 m. The length of each truss along the structure is 8.44 m. The chord members are double walled. The top chord has a ‚PI' section of 529 mm base height. The bottom chord is composed of a pair of inverted T-sections.

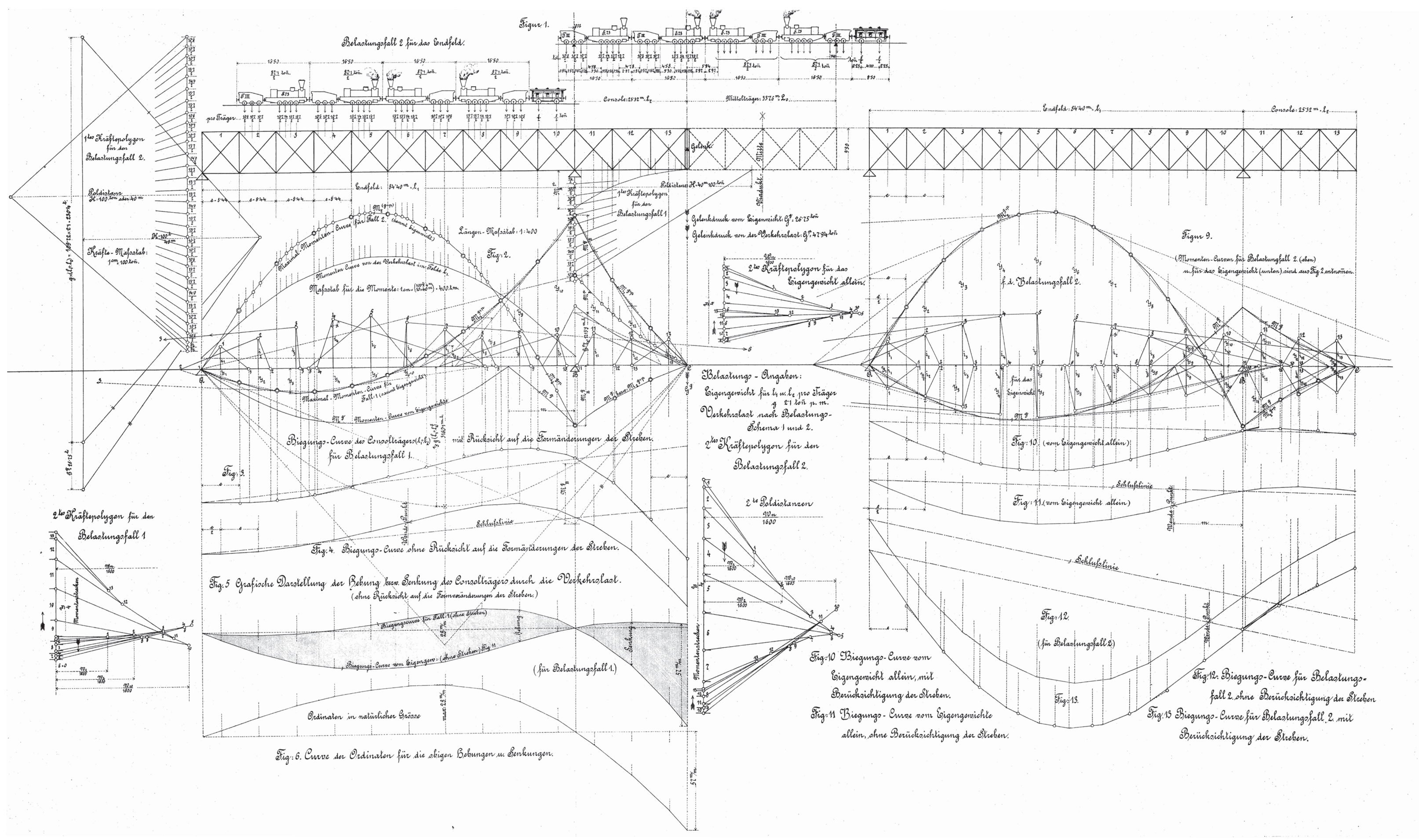
The steel structure was assembled symmetrically from the abutments towards the centre of the bridge. The approach spans were constructed on a timber truss. The cantilevers and suspended spans were assembled in a scaffold-free fashion using a derrick crane that travelled over the pre-assembled structure. The substructure is stone-made, involving the middle piers and abutments, supporting the steel structure, and the adjacent vaulted arch structures at the approach spans. The middle piers have a total height of 59.5 m, are approximately 34.3 m above the water level and are rectangular in cross-section, 7.9 × 5.0 m. The piers widen towards the pier footing. In 1960, a 0.95 m thick stone reinforcement was added up to half the height of the middle piers to protect them from the weathering effects of the water of the Orlík reservoir. In 1870, the end verticals were reinforced and an inspection footbridge built. In 1980, the hinge members of the suspended span were strengthened, and the wooden sleepers of the bridge were replaced. The last renewal of the corrosion protection coating was carried out in 1979–1981, unfortunately in poor quality (insufficient removal of corrosion and subsequent covering-over of corrosion-damaged areas with paint).

Measurements and tests

The bridge is currently being monitored according to SŽ Regulation S5, together with the construction of a new railway bridge nearby. A number of measurements and tests were carried in-situ in 2015. These included a static load test and a dynamic test using 751 series "Bardot" locomotives. As a part of the static load test, a series of strain measurements were carried out to determine the stresses in the bridge members. The results of the dynamic test were the natural modes and frequencies. The results were used to validate the numerical model and subsequently contributed to keep the bridge in limited service.



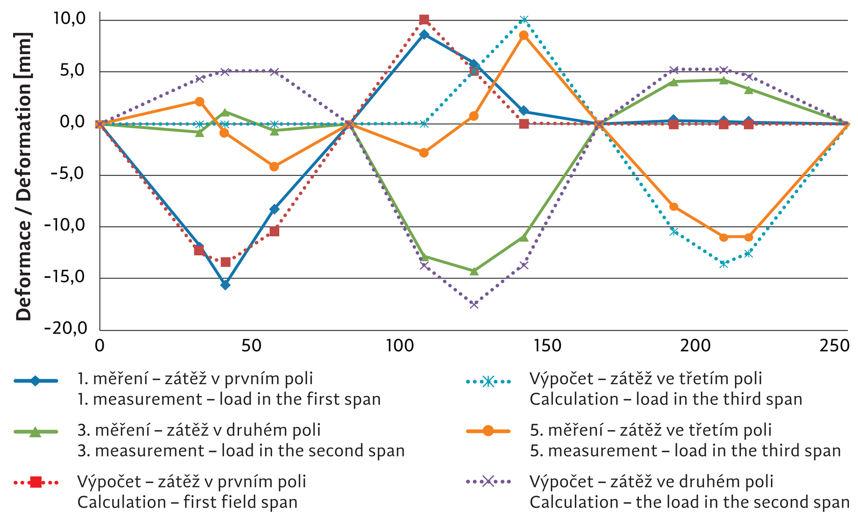
Bridge under construction before 1889



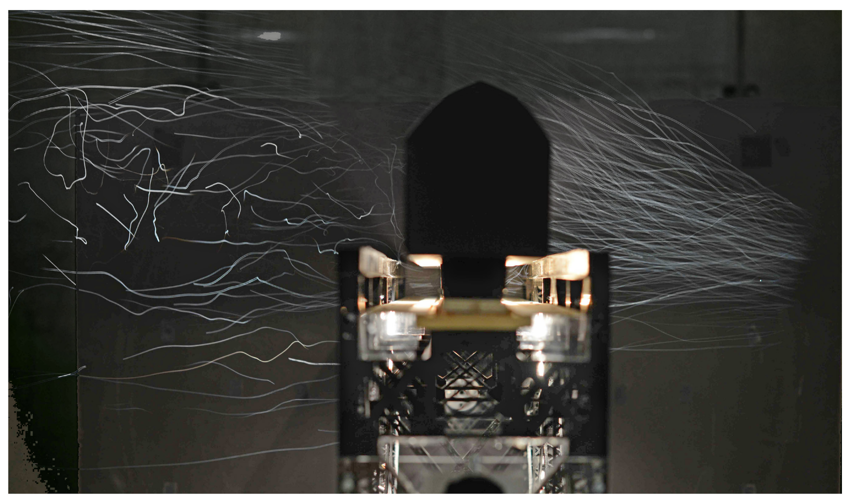
Load-bearing capacity calculation using graphic statics, 1892

The bridge was further analysed to obtain the actual wind pressure values acting on the bridge as part of the Railway Administration research project. The aim was to refine and if possible reduced wind pressure coefficients for this specific bridge with different types of passing trains.

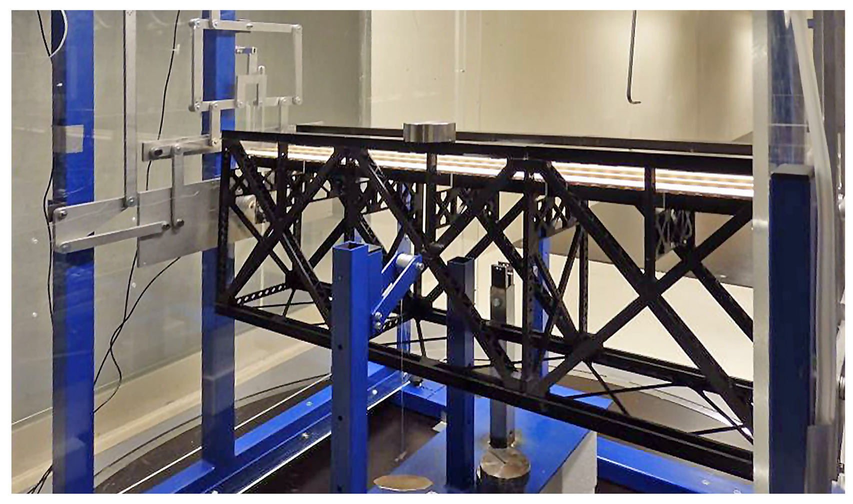
Load test



Measured vertical deflections



Wind tunnel test



Bridge model in wind tunnel

Assessment of bridge condition

The detailed inspection revealed failures limiting the service life of the bridge. In the narrow space of the gap between the angles, dirt is settling and the constant moisture accelerates the corrosion process, thus weakening the entire flange system. This affects all pier verticals and most of the tensile diagonals. Other members significantly weakened by corrosion are the stringers. Based on the analysis by SUDOP Praha, structural deficiencies found in the structural system significantly affect its behaviour. These are caused by the lack of knowledge and limited technologies in 1889, and can be considered as "inherent defects". In many cases, structural modifications are impossible due to technical reasons. In particular, the lack of horizontal bracing, the low torsional stiffness.

Regarding load-bearing capacity, the critical member of a steel structure is the end crossbeam, whose upper flange is loaded predominantly by the horizontal bending moment. Other critical members are the verticals, which cannot be reinforced. The bridge is currently in a poor condition and is operated only with a limited service life and a limited permissible load. The extent of the defects makes it unrealistic to consider its further use for rail traffic. Hence, construction of a new railway bridge alongside the old one shall commence in 2022. The existing bridge has been declared a cultural monument. Its use for pedestrian and bicycle traffic is under consideration.

Corrosion damage above abutment

Corrosion of flanges