NÁRODNÍ PAMÁTKOVÝ ÚSTAV

Working group of the Director General of the National Heritage Institute for the renovation of the Vyšehrad Railway Bridge - Conclusions

April 15. – 16. 2026

The members of the working group were concerned with the Vyšehrad Railway Bridge from the point of view of its possible repair with regard to its current condition and while respecting the requirements of Správa železnic (the railway administration), in particular to increase the clearance profile and increase the transport capacity. After inspecting the bridge and during the subsequent meeting, it formulated conclusions in three areas – A. Repair of the bridge with regard to its current condition, B. Clearance profiles, C. Solutions for the third track.

A. Repair of the bridge with respect to its current condition

1. Repairability of the bridge

- The bridge is repairable (this includes repair, replacement of elements or reinforcement of parts) with a possibility of long-term service life (at least 100 years), on the conditions of regular routine maintenance and regularly renewed anti-corrosion protection (locally continuously, overall within a horizon of 20–50 years).
- Prof. Taras's addition: In addition to the mentioned aspects concerning maintenance, the 100 years' service life horizon is conditional on the assumption that the prognoses concerning railway traffic volumes and composition on the bridge are realistically assessed and verified periodically. International best practice recommends against applying traffic load models developed for new bridge design when assessing the residual fatigue life of existing structures. This is justified by the fact that, for new construction, the as-built condition is not yet known and thus additional safety is usually included during the structural design and verification.
- Prof. Ryjáček´s addition: The service life—up to the aforementioned 100 years—depends on a number of factors and is influenced by the extent of component replacement, their anti-corrosion treatment, and the fact that, for a 100year lifespan, it is necessary to apply higher safety factors, which in effect increases the need for reinforcement or replacement of components.

2. Relocation of the bridge during repair

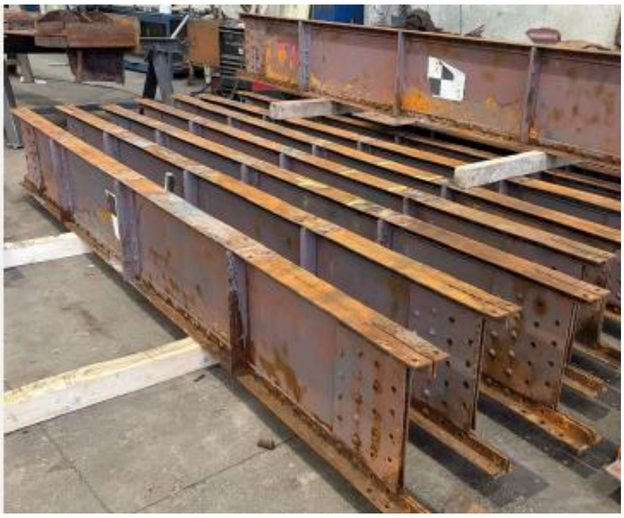
- It is recommended to relocate the bridge to a location equipped for repair. Moving the bridge will allow for the replacement of elements when not under load.
- Dismantling will allow for an objective and high-quality assessment of the elements, followed by perfect cleaning (blasting) and metallizing treatment.
- Transfer to the designated location will allow for the use of more suitable machinery than during repairs above the river, where strict noise limits also apply.
- Regarding the economic efficiency of the repair, it is appropriate to use an existing bridge structure from state material reserves as a temporary bridge during the reconstruction (repeatedly declared by Správa železnic in the past).

3. Assessment of individual elements

- In the first phase, the parts whose condition and state of corrosion will make disassembly unnecessary will be selected and those will be treated for corrosion protection as a whole.
- Damaged parts of the structure can be disassembled into individual elements and will be subjected to an objective and high-quality assessment. Experience with repair of similar

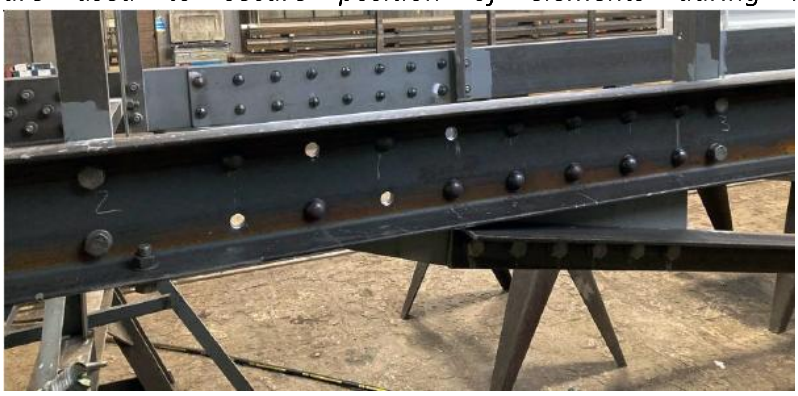
historical structures is necessary for the assessor. This disassembly is recommended in general to provide more functional corrosion protection even in the element joining points.

- In the case of excessive plastic deformation, corrosion loss or damage, an element may (from the National Heritage Institute perspective) and must (from structural perspective) be replaced.
- In case of a replacement of an element, the structure can be modified with regard to extending the service life and improving its function.
- Prof. Taras's addition: The key aspect here is the need to inspect all elements and thoroughly remove all corrosion residues through sand-blasting and other methods, before applying new corrosion protection systems. Where required, this will entail disassembling the elements entirely, i.e. removing all rivets and thoroughly sandblasting the elements even in the previous contact zones.

Above: Disassembly of a riveted bridge from the 1880 at a steelwork shop in Italy, in preparation for sand-blasting, zinc metal spraying of critical contact surfaces, new riveting and application of organic corrosion protection strata.

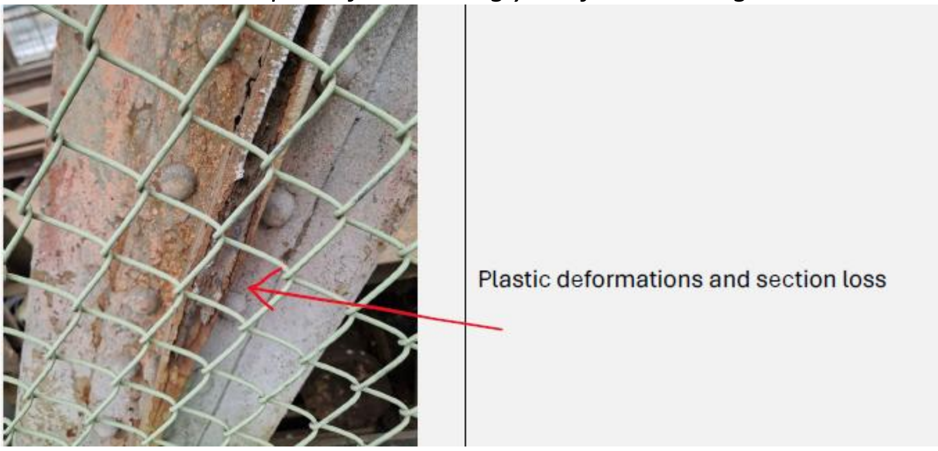
Below: New riveting of components for a bridge in Switzerland, Schneider Stahlbau AG. Bolts are used to secure position of elements during riveting and then removed.



In addition, and important aspect in the inspection of elements is that large plastic deformations in the elements, caused by the pressure in the crevices of the expanding corroding mass, should not be accepted: they indicate both a pre-damaged area that is particularly prone to further corrosion, are unlikely to be suitable for a thorough replacement

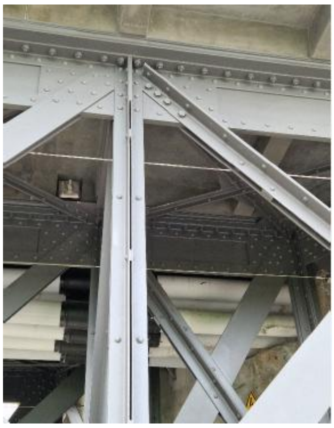
of the corrosion protection system, and – from a structural and material point of view - are potentially no longer sufficiently ductile steel elements.
Plastic deformations of the elements (e.g. of the flanges of an angle) that exceed that smaller value of 1/25 of the width or 0.5x the plate thickness of the elements should not be accepted and the corresponding elements should be replaced.

Below is an example of a strongly deformed angle in the main truss diagonals



4. Riveting technology

- The bridge should be renovated using rivets (to preserve the authenticity of the technology). According to Prof. Taras there are several companies on the market that are able to perform riveting on an industrial scale (at least two in Switzerland, others in Italy and Austria).
- The use of high-strength bolts is recommended for the (longitudinal) stringers, due to horizontal stresses that were not taken into account in the calculations at the time of the bridge construction.
- The combination of rivets and high-strength bolts on one element is not recommended given the differences in rigidity.
- Prof. Taras's addition: To be more precise: high-strength preloaded bolts (HV system) can be used in an element that also has rivets – but they should not be mixed within a single connection. See an example from a bridge in Switzerland (Wipkinger Viadukt, Zurich) that was recently refurbished using some of the strategies and methods as proposed for the Vyšehrad Bridge, where a compression diagonal was connected to the upper chord with HV bolts during the refurbishment, while the other elements in the bridge remained riveted. Also note that in this refurbishment project, corrosion-critical details were improved in the reconstruction of the elements, e.g. by avoiding points of potential water collection between gaps.



5. Bridge deck

- Inspection and diagnostics have shown the need to replace the (longitudinal) stringers, individual assessment will be necessary for the cross beams.
- Prof. Ryjáček´s addition: The replacement must be based on modifications to the bridge deck, adjustments to the bridge's width configuration, and a new track support system, as well as an assessment of their load-bearing capacity. In the case of replacing the stringers and crossbeams and installing a new track support system, it is more practical to construct the bridge deck using modern technologies.
- Prof. Taras's addition: In both cases, the joints are expected to be the critical areas. For the stringers, potential fatigue cracks were said to have been detected in the elements itself. This is what justifies that statement that these are likely to need full replacement. A replacement is justified and to be expected in such cases, as the stringers are the directly "wear elements" in any steel bridge with open deck, as is present here.

6. Material fatigue calculations and residual service life

- Differences in the results regarding remaining fatigue life stem from the methods used by the experts. Depending on assumptions regarding material properties, the assumed probabilities of component failure, the choice of component category, the modelling of joint stiffness, the level of complexity of the computational model, etc., different experts may reach very different results regarding the remaining fatigue life (with differences in the order of decades). This is inherent to fatigue limit state calculations, unlike static strength calculations, where the conclusions of different experts should be comparable.
- It is recommended that the fatigue analysis of the existing structure and the structural analysis itself be addressed separately. Foreign experts agree on the need for new, independent calculations. Prof. Ryjáček rejected this request, stating that the calculations performed were sufficient and of high quality, and he also pointed out that the commission had not been presented with these calculations from multiple authors (see appendix, point A.6 Material fatigue calculations and residual service life, To the necessity of new calculations).
- The majority of working group believes that the fatigue calculations should not be the main concern when determining the condition of the bridge.
- Continuous monitoring of the bridge is recommended even after the repairs/renovations.
- Prof. Taras's addition:
  Fatigue: When assessing the fatigue performance of an existing bridge, the simulations and calculations carried out so far, which are based on traditional design concepts used for new bridge design, can only reliably give an indication of where problems could potentially be expected – while the precision of any one number claiming to state what the "residual fatigue life" of such elements is indeed very low and questionable. This is why, for historical bridges for which the service life should be extended, international best practice does not base the assessment on these theoretical calculations. Rather, a thorough inspection of all elements and critical details, periodically repeated, needs to be carried out. Fracture-mechanical calculations can additionally be used to determine the frequency at which such inspections should be performed.
  Static resistance: Even for static resistances, there are various methods and theories for calculation – yet it is clearer how conservative or accurate they each are. Currently, there appear to be diverging opinions and statements about the extent of static "overload" of the corroded bridge. This discrepancy needs to be urgently removed and a common understanding

and agreement on what the "true" static reserves of the bridge needs to be reached. Only this will allow for an agreed-upon refurbishment planning. For this purpose, an independent re-calculation of the internal forces and the verification of the structural elements of the bridge, accounting for corrosion and other defects, is recommended.

7. Corrosion protection

- Paint systems with the highest guaranteed service life should be used.
- Stratigraphy and the retention of a reference sample (or samples) of older paints are required from the side of heritage preservation.
- Prof. Taras's addition: In recent conservation projects for riveted bridges in Switzerland, based on studies by the Chair of Durability of Engineering Materials of ETH Zurich (Prof. U. Angst), a duplex corrosion protection system was used in the most critical consisting of thermal spray zinc (TSZ) coating as base layer, followed by a duplex paint system (primer + intermediate coats with micaceous iron oxide pigments + topcoat), applied after disassembly and grit-blasting to Sa 2½, with re-riveting prior to the application of the intermediate and top coats.
  This same system is also currently being applied to the Italian bridge shown in photos above.
  Hot-dip galvanizing, on the other hand, should not be applied to historic elements due to the risk of embrittlment and the appearance of cracks. This technique should be used, as part of a duplex system, only for the new, replacement elements.

B. Clearance profiles

The issue of the clearance profile was discussed and the group did not come to a unified conclusion.

- Most members of the working group recommend maintaining the existing profile (and therefore also maintaining the crossbeams, that will not need to be changed due to their lifespan). Prof. Ryjáček recommends widening the bridge according to the requirements of SŽ to ZG-C (which is already reduced compared to ČSN 736201), noting that the time during which the bridge will be in storage is ideal for any modifications.
- The working group cannot decide on the necessity of the ZG-C profile. It is also necessary to specify whether the increase in the clearance profile is based on the requirements of the Ministry of Defence (from a transportation perspective) or Správa železnic (for safe movement of persons on the bridge).
- As for Správa železnic's requirement, it is necessary to request a justification. It is proposed to compensate for the requirement for safe movement along the tracks by expanding the walking area to the width of the existing truss structure.
- If it is nevertheless necessary to expand the clearance profiles, then from a technical point of view the solution lies in replacing or extending the cross members and possibly in adequately modifying the pillar heads but these would have to be significantly reinforced, at least. From a heritage preservation perspective, it will then be necessary to assess whether the expansion of the bridge and the change in proportions are acceptable.

C. Solution for the third track

The working group concluded that if it is necessary to increase the transport capacity, it is possible to solve this by placing a third track on a new bridge. To preserve the historic values of the Vyšehrad Bridge the ideal conditions would be:

- location on the southern (upstream) side,
- location at a minimum distance from the old bridge,

- modern architectural and engineering solution with a subtle straight structure, with a minimalist expression.

According to Prof. Ryjáček the placement of the new bridge on the southern side is not viable (see Appendix, point C. Solution for the third track, To the issue of a new bridge.).

Recommendation

The bridge renovation contractor should have experience in repairing similar historical structures and protected historic buildings.

Conclusion

Based on the above conclusions of the working group, the conditions for the repair of the cultural monument Vyšehrad Railway Bridge will be defined in accordance with Act No. 20/1987 Coll., on state heritage preservation.